User's Manual

US300PM
Ultrasonic Flowmeter, Portable Type

IM 01G05B02-01E

YOKOGAWA
Yokogawa Electric Corporation

IM 01G05B02-01E
1st Edition

US300PM can be operated in the language of your choice. Please refer to chapter 4.5.

US300PM blendet seine Anzeigen in einer durch Sie zu wählenden Sprache ein. (Siehe Kapitel 4.5).

Il est possible de sélectionner la langue utilisée par US300PM à l'écran. Veuillez consulter le chapitre 4.5.

Displayteksten for US300PM findes i måleapparatet på sprog dansk, tysk, engelsk, fransk. Brugeren kan vælge et af disse sprog (se afsnit 4.5).

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Yokogawa US300PM, Firmware-Version V5.xx

IM 01G05B02-01E, 1st edition

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Table of Contents

1 Introduction 3
- 1.1 Regarding this Manual 3
- 1.2 Safety Precautions 3
- 1.3 Warranty 3
- 1.4 How to Use this Manual 4

2 Handling Precautions 7
- 2.1 Scope of Delivery 7
- 2.2 Unpacking 8
- 2.3 General Precautions 8
- 2.4 Cleaning 8
- 2.5 Battery Replacement 8
- 2.6 Battery Handling 9
- 2.7 Storage 9

3 The Flowmeter 11
- 3.1 Overview 11
- 3.2 Measuring Principle 11
- 3.3 Applications 12
- 3.4 Description of the Flowmeter 13
- 3.5 Power Supply 14

4 Getting Started 15
- 4.1 Switching ON/OFF 15
- 4.2 The Keyboard 15
- 4.3 The Menus 17
- 4.4 HotCodes 19
- 4.5 Selecting the Language 19
- 4.6 BATTERY LED 19
- 4.7 SIGNAL LED 19
- 4.8 Automatic Power Off 20

5 Basic Measurement 21
- 5.1 Selection of the Measuring Point 21
- 5.2 Input of the Parameters 24
- 5.3 Input of the Parameters of the Pipe 25
- 5.4 Input of the Parameters of the Medium 27
- 5.5 Selection of the Measuring Channels 29
- 5.6 Selection of the Sound Path Factor 29
- 5.7 Mounting and Positioning of the Transducers 30
- 5.8 Starting the Measurement 34
- 5.9 Stopping the Measurement 35
- 5.10 Recognition of Flow Direction 35

6 Displaying the Measured Values 37
- 6.1 Selection of the Physical Quantity and of the Unit of Measurement 37
- 6.2 Toggling between the Channels 38
- 6.3 Configuration of the Display 38
- 6.4 Transducer Distance 39

7 Advanced Measuring Functions 41
- 7.1 The Damping Factor 41
- 7.2 Flow Totalizers 41
- 7.3 Upper Limit for Flow Velocities 43
- 7.4 Cut-off Flow 43
- 7.5 Reckoning Channels 44

8 Storage and Output of Measured Values 49
- 8.1 Measuring with the Data Logger Function 49
- 8.2 Offline Output of Measured Values 51
- 8.3 Online Output of Measured Values 51
- 8.4 Format of the Serial Output 52
- 8.5 Serial Output Settings 52
- 8.6 Deletion of Measured Values 53
- 8.7 Settings of the Data Logger Function 53
- 8.8 Available Memory 55

9 Working with Parameter Records 57
- 9.1 Saving Parameters in a Parameter Record 57
- 9.2 Loading Parameter Records 58
- 9.3 Deletion of Parameter Records 58
- 9.4 ParaPool Function 59

10 Libraries 63
- 10.1 Editing the Selection Lists 63
- 10.2 Defining New Materials and Media 65

11 System Settings 71
- 11.1 Setting the Internal Clock 71
- 11.2 Settings for the Dialogues and Menus 72
- 11.3 Measurement Settings 74
- 11.4 Setting the Contrast 76
- 11.5 Instrument Information 76
- 11.6 Charging the Battery 77

12 Wall Thickness Measurement 79
- 12.1 Activating the WTM Mode 79
- 12.2 Parameter Input 80
- 12.3 Measurement 81

13 Time-programmable Measurement 85
- 13.1 Enabling and Disabling 85
- 13.2 Input of the Start Time 85
- 13.3 Input of the Stop Time 86
- 13.4 Measuring with the Time-programmable Mode 88
- 13.5 Storage of Measured Values 90
- 13.6 Online Output 90

14 Measuring the Sound Velocity of the Medium 91
- 14.1 Displayed Information 92

15 Process Outputs 95
- 15.1 Installation of a Process Output 95
- 15.2 Defining the Error Value Delay 99
- 15.3 Circuits of Process Outputs 99
- 15.4 Activation of an Analogue Output 100
- 15.5 Activation of a Pulse Output 101
- 15.6 Activation of an Alarm Output 101
- 15.7 Deactivating an Alarm Output 107

16 Troubleshooting 109
- 16.1 Error Messages 109
- 16.2 US300PM doesn't react anymore 113
- 16.3 No signal can be detected 113
- 16.4 Measuring Data Substantially Differ from the Expected Values 114

A Standard Specifications 117

B Reference 125

1 Introduction

1.1 Regarding this Manual

This manual has been written for the personnel operating the US300PM flowmeter. It contains very important information about the instrument, how to handle it correctly, how to avoid damaging it and how to avoid injury. Always keep this manual at hand. Get acquainted with the safety rules and the handling precautions. Make sure you have read this manual thoroughly and understood how to operate the instrument before operating the instrument.

- The contents of this manual may be changed without prior notice.
- All rights reserved. No part of this manual may be reproduced in any form without Yokogawa's written permission.
- Yokogawa makes no warranty of any kind with regard to this material, including, but not limited to, implied warranties of merchantability and suitability for a particular purpose.
- If any question arises or errors are found, or if any information is missing from this manual, please inform the nearest Yokogawa sales office.

1.2 Safety Precautions

For the protection and safety of the operator and the instrument or the system including the instrument, please be sure to follow the instructions on safety described in this manual when handling this instrument. In case the instrument is handled in contradiction to these instructions, Yokogawa does not guarantee safety.

The following safety symbol marks are used in this Manual:

Note:	The notes contain important information which help you use your instrument in an optimal way.

Attention!	This text gives you important instructions which should be respected in order to avoid failure or damaging the instrument. Proceed with attention!

	This text denotes an action which could result in injury or death of personal. Proceed cautiously!

Respect these safety precautions!

1.3 Warranty

- The warranty shall cover the period noted on the quotation presented to the purchaser at the time of purchase. Problems occurred during the warranty period shall basically be repaired free of charge.
- In case of problems, the customer should contact the Yokogawa representative from which the instrument was purchased, or the nearest Yokogawa office.
- If a problem arises with this instrument, please inform us of the nature of the problem and the circumstances under which it developed, including the model specification, the serial number and the factory number. Any diagrams, data and other information you can include in your communication will also be helpful.

- Responsible party for repair cost for the problems shall be determined by Yokogawa based on our investigation.
- The Purchaser shall bear the responsibility for repair costs, even during the warranty period, if the malfunction is due to:
  - Improper and/or inadequate maintenance by the purchaser.
  - Failure or damage due to improper handling, use or storage which is out of design conditions.
  - Use of the product in question in a location not conforming to the standards specified by Yokogawa, or due to improper maintenance of the installation location.
  - Failure or damage due to modification or repair by any party except Yokogawa or an approved representative of Yokogawa.
  - Malfunction or damage from improper relocation of the product in question after delivery.
  - Reason of force majeure such as fires, earthquakes, storms/floods, thunder/ lightening, or other natural disasters, or disturbances, riots, warfare, or radioactive contamination.

1.4 How to Use this Manual

1.4.1 Construction of this Manual

Chapter 1 Introduction:

This chapter describes how to use this manual and the meaning of the precautions in this manual. It also describes the warranty for the product.

Chapter 2 Handling Precautions:

This chapter describes how to unpack and check the delivered goods and also daily handling precautions for the product and accessories.

Chapter 3 The Flowmeter:

This chapter describes the principle and the feature of this product. It also tells you the names of each part of the product.

Chapter 4 Getting Started:

This chapter describes how to use the keyboard and display on the front panel and the functions of each key.

Chapter 5 Basic Measurement:

This chapter describes how to start the basic measurement including the process of installing the transducers and setting the parameters.

Chapter 6 Displaying the Measured Values:

This chapter describes how to display the measured values or some other information on the display. It also describes how to change the physical quantity and the unit for the measurement.

Chapter 7 Advanced Measuring Functions:

This chapter describes some advanced measuring functions like flow totalizer, cut-off flow, the calculation using the measured value of the two channels.

Chapter 8 Storage and Output of Measured Values:

This chapter describes how to store the measured values in the internal memories and how to output the measured results to a PC or a serial printer.

Chapter 9 Working with Parameter Records:

This chapter describes how to define the specific measuring point data as the parameter records which is for the convenience of your specific measuring tasks.

Chapter 10 Libraries:

This chapter describes how to define the specific parameters for materials and media. It describes how to make a own list of the materials and media for the convenience of your specific measuring tasks.

Chapter 11 System Settings:

This chapter describes the settings on the system functions. If you would like to get the information and to activate some additional functions of the product, please refer to this chapter.

Chapter 12 Wall Thickness Measurement:

This chapter describes how to measure the wall thickness or the longitudinal sound velocity in the pipe material using the optional measurement probe.

Chapter 13 Time-programmable Measurement:

This chapter describes how to use timer-start and stop function for the measurement.

Chapter 14 Measuring the Sound Velocity of the Medium:

This chapter describes how to measure the sound velocity in the medium and how to store it as one of the medium parameters for the flow measurement (refer to section 5.3).

Chapter 15 Process Outputs:

This chapter describes how to use the process outputs equipped in the product. The current outputs, frequency output, or binary outputs (for pulse or alarm) come equipped with the product when you specified in your order. These outputs must be installed and activated by the software settings when you use them. The description here contains how to define the types and properties for the alarm outputs.

Chapter 16 Troubleshooting:

This chapter describes the troubleshooting of the product. The description here contains the overview of error messages you might encounter and how to deal with them.

Appendix A Standard Specifications:

The tables and the figures for the standard specifications of the product are shown here.

Appendix B Reference:

The tables and the figures for the properties of the materials and media are shown here.

1.4.2 The Basic Measurement

The chapter 5 describes the process of the basic measurement, by which you will get to know how to simply display the flow values of the measurement. This process is basic and common also with the advanced measuring functions. Therefore, please read the chapter 5 thoroughly and fully understand the process of the basic measurement.

Steps of the basic measurement:

A. Connecting Cables to the Instrument (refer to section 3.4 and 4.1):

Connect the cables for power supply and transducers to the instrument.

Turn the power on.

B. Selection of the measuring point (refer to section 5.1):

Select the measuring point on the pipe to mount the transducers.

C. Entering the parameters of materials and media (refer to section 5.2 to 5.4):

Enter the parameters of the material and medium at your measuring point.

D. Selection of the measuring channels (refer to section 5.5)

Activate the channels you want to use for the measurement and select the settings of each measuring channel in the following order.

D-1. Selection of the sound path factor (refer to section 5.6)

Enter the number of transit path of the ultrasonic signal through the medium in the pipe.

The instrument calculates the transducer distance and indicates the positional relationship of transducers to be mounted on the pipe.

D-2. Mounting and positioning of the transducers (refer to section 5.7.1 and 5.7.2)

Mount and position the transducers using calculated value of the distance and indicated positional relationship.

D-3. Adjusting the transducer distance (refer to section 5.7.3)

Adjust the transducer distance properly by moving them slightly referring to the bar graph displayed on the product that shows the signal strength or quality.

E. When you enter the current transducer distance again and finish the above procedure for all the channels you are going to use, the measurement will automatically start.

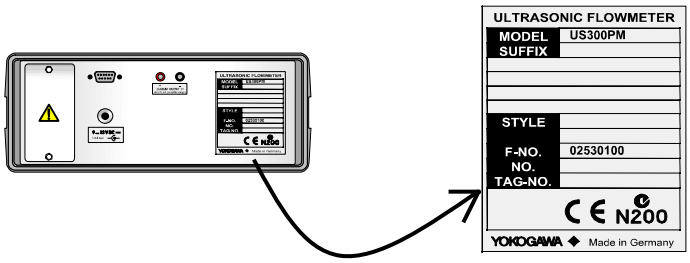
2 Handling Precautions

2.1 Scope of Delivery

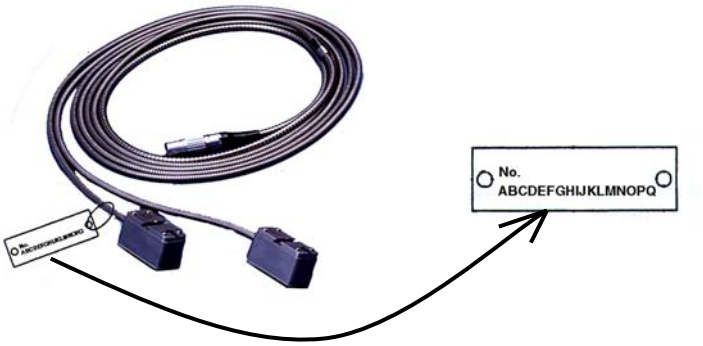
This instrument has already been tested thoroughly at the factory. When the instrument is delivered, please proceed to a visual control to make sure that no damage has occurred during transportation.

The model and the specifications of the instrument are shown on the name plate on the rear side of the instrument. The model and the specifications of the transducers are shown on the top of transducers and on the serial number plate hanging on the cable. Please make sure that the specifications of the instrument that was delivered correspond to the specifications given on the purchase order (refer to Model and Suffix Code in Appendix A).

Flowmeter:



Transducers:



In the minimum requirement, the following items of standard supply are in the package:

Flowmeter: US300PM-Axx-2-N/ ##

- User's manual	1
- Basic instrument, including built-in battery set (fully charged)	1
- Power adapter and battery charging unit with integrated cables for connection with instrument and power supply	1
- Transportation case	1

Transducers: US300PT-x-xx-x-x-x/ ##

- Transducers as per order, with integrated cables	1*
- Mounting fixtures	1*
- Fixing chains and Extensional fixing chains	1*
- Tube of acoustic coupling compound	1*

Note: x : means some numeral or character of Suffix Code.
/## : means an option.
* : number according to your particular order.

Your package may contain other components according to your particular order.

Please make sure that the specifications of these components correspond to the specifications given on the purchase order.

If you have any problems or questions, please contact your local Yokogawa sales office. When contacting Yokogawa, always have the following information at hand:

- model (MODEL)
- serial number (No.)
- factory number (F-No., refer to section 11.5)
- the number of the firmware version (refer to section 11.5).

2.2 Unpacking

Unpack the transport case when it lies flat on its large bottom surface in order to avoid that the instrument and its accessories fall out.

2.3 General Precautions

US300PM is a precision measuring instrument and it must be handled with care. To obtain good measurement results and in order not to damage the instrument, it is important that great attention is paid to the instructions given in this User's Manual, and particularly to the following points:

- Protect the instrument from excessive shock.
- Do not open the housing without Yokogawa's authorization.
- Use a correct external power supply when not using the battery supplied by Yokogawa.
- Make sure to work under correct ambient and operating temperatures (refer to Standard Specifications in Appendix A).
- Handle the charging unit and the battery correctly (see section 2.6).
- Respect the degree of protection (refer to Standard Specifications in Appendix A).
- The power adapter/battery charging unit is not moisture-proof. Use it only in dry rooms.
- Keep the transducers clean.
- Manipulate the transducer cables cautiously (avoid excessive cable bend).

2.4 Cleaning

Clean the instrument with a soft cloth. Do not use detergents.

Remove traces of acoustic coupling compound from the transducers with a paper tissue.

2.5 Battery Replacement

To replace the battery:

- Unscrew the two cap nuts (5,5 mm) of the battery compartment cover (see picture in section 3.4.2) and remove the cover. Make sure not to lose the screws!
- Unplug the connector.
- Remove the battery pack by pulling on the black strap.
- Insert the new battery pack. Make sure to insert the battery pack in the instrument with the connector free end first.
- Plug the connector again. Take care to plug the connector correctly, it prevents to reverse the polarity.
- Screw the battery compartment cover back on the instrument.

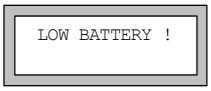
Attention!	• Use only the battery set authorized by Yokogawa. This battery set can be ordered from Yokogawa or an authorized dealer. • The protective degree IP54 of the flowmeter is given only if the battery compartment cover is screwed on the housing.

2.6 Battery Handling

Note:	If the battery operating time has become a lot shorter than specified, please replace the battery.

Taking the following precautions will prolong the battery's life expectancy:

- For longer periods of storage, batteries should be kept at low temperatures (0°C to 10°C). Storage in cool conditions will lower the self-discharging by a factor of 1/10.
- Store the battery set only in charged condition.
- To avoid the so-called *Memory Effect* (the charging of the batteries in ever shorter times with a low charging capacity), discharge the batteries fully in a smooth and continuous manner before a new charging cycle is being started. Do not deep-discharge batteries.

Attention!	• Use only the battery set authorized by Yokogawa. This battery set can be ordered from Yokogawa or an authorized dealer. • Take care to plug correctly the connector which prevents to reverse the polarity. • Before recharging, discharge the battery set as far as possible in order to avoid over-charging. US300PM signalizes that the battery is discharged as follows: 

2.7 Storage

Always pack the instrument and its accessories into the respective compartments of the transport case after measurements have been performed.

Wipe the transducers clean of traces of acoustic coupling compound.

Tilt the instrument handle towards the upper front face of US300PM and not onto the top side of the housing. This avoids scratches on the enclosure, caused by the instrument handle, during transport. Avoid excessive bends of transducers cable especially when closing the transport case top cover.

3 The Flowmeter

3.1 Overview

US300PM is a flowmeter that uses ultrasonic signals to measure the flow in pipes or conduits. It can measure the following quantities:

-the flow velocity,

-the volume and mass flow rate and their totalization,

-the sound velocity of a medium.

With an optional probe, US300PM can also measure the thickness of pipe walls.

The transducers can be operated at temperatures between -30°C and 130°C. With specially designed high temperature transducers, the operating temperature range can be extended up to 200°C. Measurement can be made on all commonly used pipe materials such as steel, synthetic material, glass or copper. Pipe diameters may range from 25 up to 3000 millimeters (depending on transducer type). The two clamp-on transducers allow for non-invasive measurement that do not affect the pipework or the liquid to be measured. They are small, lightweight and also very robust.

US300PM is a portable, battery operated measuring instrument suitable for field use. US300PM has protection degree IP54 and is therefore suitable for monitoring tasks under difficult environmental conditions.

US300PM can be operated in different languages. A backlit display shows input data and measurements results as well as operational errors. The menus guide the user through the parameter setup, measurement and data storage. You can define the materials and media which will be offered in the selection lists of the program branches and the order in which they will appear (limitation of the long selection lists of the internal properties data bank). An integrated coefficient storage which can be partitioned according to your needs keeps self-defined properties of materials and media.

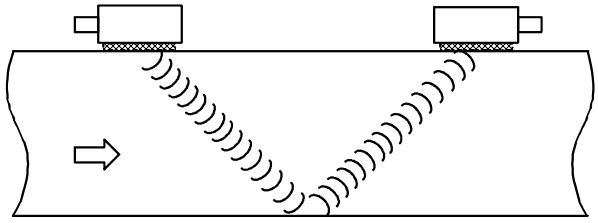
US300PM can log up to 27,000 measured values and up to 14 different sets of site parameters. Furthermore, up to 80 memory places for measuring point parameters can be used.

US300PM has a serial interface which allows the transfer of the measured data to a PC or to a printer. The data transferred to a PC can be processed by EXCEL or any other data analyzing program.

US300PM features an integrated measuring point multiplexer which enables simultaneous flow measurement and reckoning measurement (channel A - channel B for example).

3.2 Measuring Principle

US300PM uses ultrasonic signals for the measurement of liquid flow, employing the so-called transit time method. Ultrasonic signals are emitted alternatively in the direction of flow and against it.



The flowing medium causes different transit times of these two sound signals. From the time difference, **US300PM** calculates the average flow velocity along the path of acoustic propagation. Performing a flow profile correction, **US300PM** then calculates the average flow velocity through the cross sectional area, which is proportional to the volume flow.

This effect can be observed over the complete range of flow velocities found in technical applications. This allows **US300PM** to cover a wide flow measuring range and also to determine the direction of flow within the pipe.

As ultrasonic waves also propagate in solid materials, the transducers (alternatively operating as sound transmitters and receivers) can be mounted onto the outside of pipe walls, allowing for non-invasive measurement.

In order to avoid wrong measurements, **US300PM** tests with its special electronics the incoming ultrasonic signals for their usefulness for the measurement and evaluates the plausibility of the measured values.

The microprocessor integrated in **US300PM** controls the complete measuring cycle, eliminating disturbance signals by statistical signal processing techniques.

3.3 Applications

US300PM can always be used where the pipe wall and the liquid to be measured are sonically conductive. This is true for pipe walls consisting of homogeneous material, and for liquids which carry only small amounts of solid particles or gas bubbles. There is no dependency on electrical parameters of the fluid such as conductivity or dielectric constant.

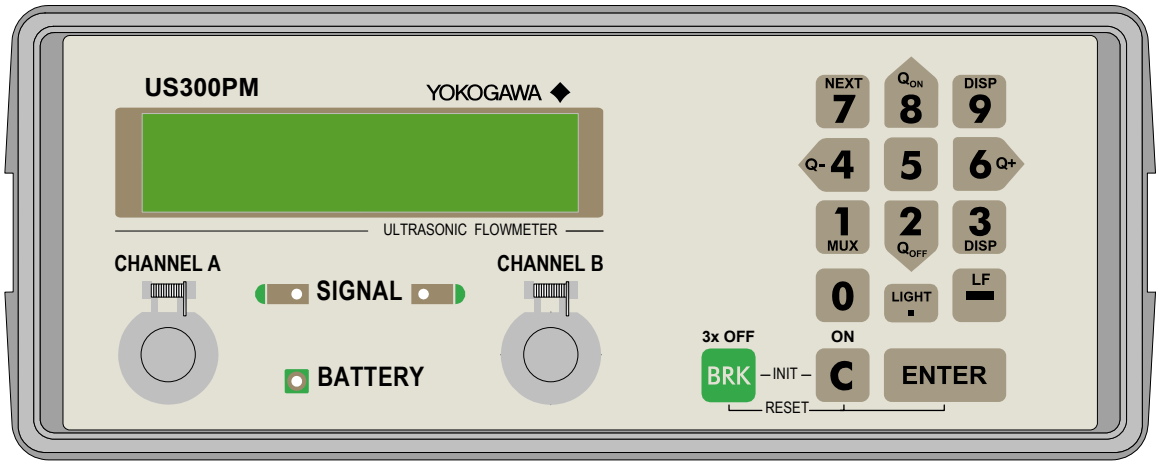
ADVANTAGES:

- Non-invasive methods permits safe measurement on aggressive or high temperature media flowing in closed conduits.
- Flow values can be measured without interruption of the process.
- The installation does not require any alterations to the pipe system.
- Straightforward mounting of the transducers and battery operated portable instrument allow flow measurements at various locations in the plant and on pipes with different diameters. The measurement does not influence the cross-sectional area of the pipe nor the actual flow conditions.

3.4 Description of the Flowmeter

3.4.1 Front Panel

2 x 16-digit LCD display, backlit



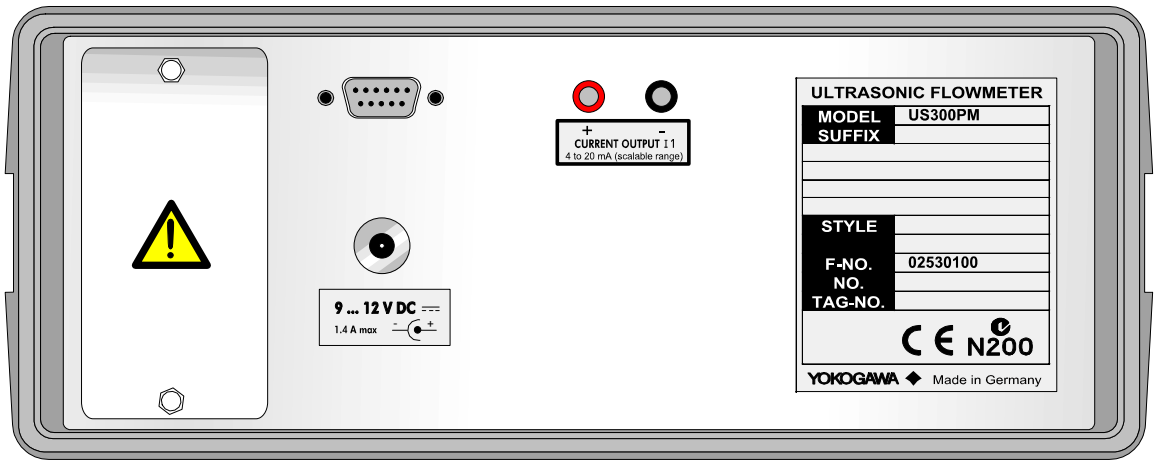
- Connection port for flow transducers of channel A or wall thickness sensor.
- Status indicators (see sections 4.6 and 4.7)
- Connection port for flow transducers of channel B or wall thickness sensor.
- Keyboard (see section 4.2)

3.4.2 Rear Panel

Process outputs (see chapter 15)

Serial interface

Name plate



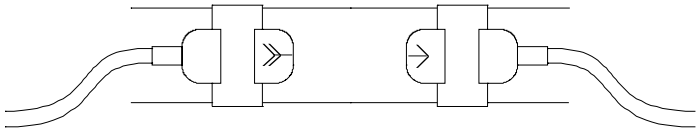
- Battery compartment cover
- Connection socket for power adapter/battery charging unit

3.4.3 The Transducers

The two transducers are connected to the instrument by a round connector.

There is a different engraving on the top of each transducer. The transducers are mounted correctly if the engravings on the two transducers are forming an arrow together. The transducer cables should then show in opposite directions.

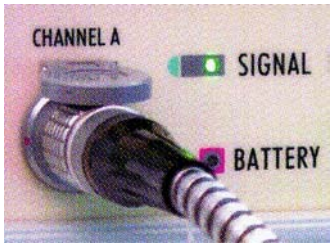
Later, the arrow, in conjunction with the indicated measured value, will help you to determine the direction of flow.



Attention!	The engravings should also form an arrow if the two transducers are mounted on opposite sides of the pipe wall.

Connection

- Pull up the socket cover of the channel on which you want to connect the transducers.
- Insert the connector of the transducer cable in the socket. The red point on the connector should face the red marking on the socket.



3.5 Power Supply

The chargeable NiCd-batteries guarantee an operating time of approximately 14 hours. If required, the flowmeter can operate from an external power supply of 100 to 240 VAC. The power adapter/battery charging unit can be used for this purpose.

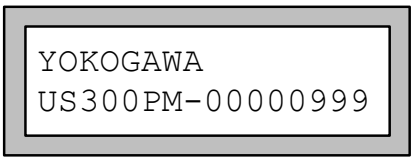
Attention!	The power adapter/battery charging unit is not moisture-proof. Use it only in dry rooms.

4 Getting Started

4.1 Switching ON/OFF

Press this key to switch US300PM ON.

Pressing **BRK** three times will switch US300PM OFF.



After US300PM has been switched on, a message will appear indicating which transducer was detected on which channel. The serial number of the instrument is then displayed for a second or two.

4

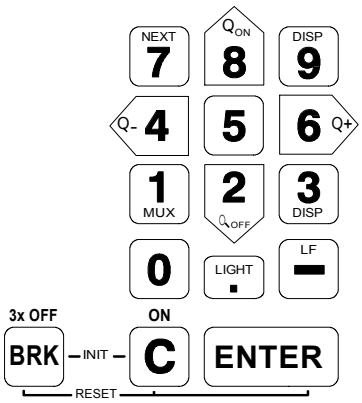
Note!	No data can be entered while the factory number is displayed.

After initialization, the main menu in the actually selected language version appears.

US300PM can be operated in the language of your choice. Please refer to section 4.5.

4.2 The Keyboard

The US300PM's operator interface consists of a keyboard and a two-line display (16 digits per line). The keyboard features three function keys and 12 keys for numerical data input.



Several keys have double functions. They can be used for INPUT as well as for SELECTION**.**

In SELECTION mode, for example, the arrow-shaped numerical keys operate as cursor keys.

In INPUT mode, they can be used for the input of numbers and characters.

4.2.1 Key Operations

General functions

ON C	1 x C = Switches the flowmeter ON.
LIGHT ■	Switches the background lighting ON/OFF.
BRK – INIT – C ENTER (RESET)	RESET: Press these keys simultaneously to recover from an error. This has the same effect as restarting the unit. Data will not be affected.
BRK – INIT – ON C	INIT (coldstart): Pressing these keys simultaneously while switching the flowmeter ON until the main menu appears will initialize US300PM. Most parameters and settings are reset to the factory default values. The memory will not be cleared.
3x OFF BRK	3 x **BRK** = Switches the flowmeter OFF. In battery mode, an automatic switch-off routine is active. If the flowmeter has been expecting a keyboard action for a period of 10 minutes, an automatic switching off process will be activated.
BRK	Interrupts the measurement and calls the main menu.

Attention!	Be careful not to interrupt an ongoing measurement by inadvertently pressing **BRK**!

Menu selections

BRK	1 x **BRK =** Calls the main menu.
Q- 4 6 Q+	Selecting the menu entry at the left or at the right of the currently highlighted one.
Q_{ON} 8 2 Q_{OFF}	Scrolling upwards or downwards through the menus.
ENTER	Confirmation of the selected entry. The corresponding program branch appears.

Input of numerical values

0 to DISP 9	Input of the numerical value shown on the key
LF –	Sign for the input of negative data
LIGHT ■	Decimal point
C	Deletion of data. After the deletion of data, the previous value will be displayed.
ENTER	Confirmation of input.

Input of text

Q- 4 6 Q+	Selection of the position of the character to be input.
DISP 9	Changes the currently selected character to an 'A'.

3 DISP	Changes the currently selected character to a 'Z'.
5	Changes between small and capital letters.
2 Q_{OFF}	Moving to the next ASCII character.
Q_{ON} 8	Moving to the previous ASCII character.
0	Deleting the character currently shown and inserts a blank space.
NEXT 7	To automatically scroll upwards through the selected restricted ASCII character set. The character changes every second. The scrolling can be interrupted by pressing any other key.
1 MUX	To automatically scroll downwards through the selected restricted ASCII character set. The character changes every second. The scrolling can be interrupted by pressing any other key.
ENTER	Finishes editing.

4.3 The Menus

4.3.1 The Main Menu

After switching on and initialization, the main menu appears on the first line of the display. The main menu has following entries: PAR (parameter), MEA (measuring), OPT (output options) and SF (special functions), corresponding to the four different program branches. The actually selected program branch is displayed in capital letters between arrows. The full name of the program branch is displayed on the second line.

Use keys Q- 4 and 6 Q+ to select a program branch. Confirm by pressing **ENTER**.

4.3.2 The Program Branches

In the PARAMETER program branch, you can enter the parameters of the pipe and of the medium for the different measuring channels.

The MEASURING program branch leads you through the different steps of the measuring process.

In the OUTPUT OPTIONS branch, you can set all output relevant parameters, such as the physical quantity to be displayed during measurement and the measurement unit used for display for example.

The SPECIAL FUNCTION branch contains all functions that are not directly related with the basic measurement.

If a vertical arrow (⇳) is displayed beside a menu option, this menu option contains a scroll list. This list is displayed on the second line.

Use the arrow keys 8 (Q_{ON}) and 2 (Q_{OFF}) to scroll through the list.

Note:	You can return to the main menu at any time by pressing BRK.

In this manual, all program entries and keys will appear in capital letters. Program entries are in typewriter characters ("PARAMETER"). Submenus are separated form the main menu entry by a backslash.

To get to the SPECIAL FUNCTION \ SYSTEM SETTINGS \ MEASURING menu for example:

- Select the SPECIAL FUNCTION program branch and confirm this selection by pressing **ENTER**.
- Using the 8 (Q_{ON}) and 2 (Q_{OFF}) keys, select the SYSTEM SETTINGS option of the scroll list and confirm by pressing **ENTER**.
- Using the 8 (Q_{ON}) and 2 (Q_{OFF}) keys, select the MEASURING option of the scroll list and confirm by pressing **ENTER**.

4.3.3 Display Templates

US300PM displays the result of keyboard entries, program steps and shows measured values on four different display templates.

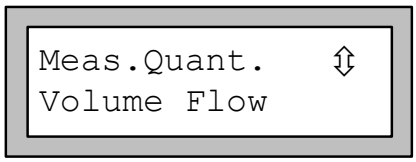
1 Horizontal SELECTION MODE

US300PM requests a horizontal selection. The selected menu is displayed in capital letters and between arrows.

Use keys 4 ($Q-$) and 6 ($Q+$) for scrolling.

2 Vertical SELECTION MODE (scroll menu)

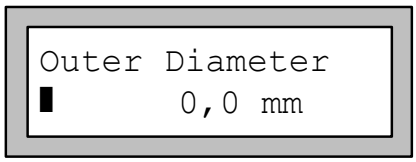
(US300PM starts the scroll menu at that display which you left last.)



US300PM requests a vertical selection. This is indicated by the arrow "⇳" at the upper right of the display.

Use keys 8 (Q_{ON}) and 2 (Q_{OFF}) for scrolling.

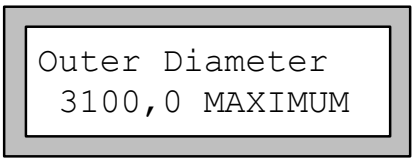
3 INPUT MODE



US300PM requests the INPUT of data. The cursor flashes at the left of the input display line.
Use numeric keys, the decimal point key, or the sign key for entering data.

Use C to correct input mistakes.

4 Display of information and error messages



Note should be taken if the display contains information or error messages.

The messages can be confirmed by pressing **ENTER**.

4.4 HotCodes

A HotCode is a specific key sequence which has to be entered to activate some settings. Enter HotCodes in the main menu just after the flowmeter has been turned on. The HotCode itself is not displayed during entry.

4.5 Selecting the Language

US300PM can be operated in one of the languages listed below. The language can be selected with the following HotCodes (see section 4.4). Depending on the specific technical characteristics of your instrument, some of the languages listed below might not be implemented.

Language	**HotCodes**		
909031	for Dutch,	909047	for Norwegian
909033	for French,	909048	for Polish,
909042	for Czech,	909049	for German.
909044	for English,	909090	for Turkish
909045	for Danish,		

When the last digit has been entered, the main menu appears in the selected language and US300PM greets accordingly. The selected language remain activated even after switching the unit OFF and ON again.

Attention!	The display will appear in the factory preset language version after instrument reset (key combination BRK – INIT – C).

Should you have entered the HotCode for the language version incorrectly, switch the unit off by pressing **BRK** three times, then on again. Enter the HotCode again.

4.6 BATTERY LED

OFF	The flowmeter works under normal operating conditions (battery or external power supply).
LED on	Battery is being charged.
LED flashes, long intervals	Battery voltage is insufficient. Measurements are impossible. Battery set must be charged or changed.
LED flashes, short intervals	Error during battery charging, e.g. no external voltage present.

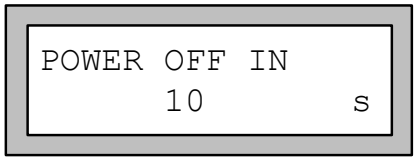
4.7 SIGNAL LED

OFF	The flowmeter works offline.
LED green on	The signal received by the channel is sufficient for measurements.
LED red on	The signal received by the channel is insufficient for measurements.

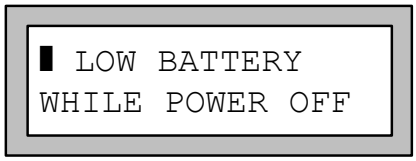
4.8 Automatic Power Off

When the flowmeter is battery operated, an automatic power off function is activated. If the flowmeter has been expecting an action (key press or reception of a character from a PC on the RS232 interface) for a period of 10 minutes, an automatic switching off process will be activated. The flowmeter won't be switched off during measurement unless the batteries run low. "During measurement" means here that the measuring process has been started by entering the precise transducer distance and pressing **ENTER** - no matter whether this measuring process is successful or not.

Upon activation of the power off process, an acoustic signal is emitted and following warning is displayed:



While the countdown runs, you can press any key to avoid switching off.



If this information appears after US300PM has been switched ON again after automatically switching off, it indicates that the unit has switched itself off because of low batteries.

Note:	The automatic power off function is not activated when the instrument works with an external power supply.

5 Basic Measurement

In a first step, select the measuring point according to the recommendations given in section 5.1, making sure that the temperature at the selected location is within the operating temperature range of the transducers (see Standard Specifications in Appendix A).

Select afterward the location of the instrument within cable reach of the measuring point. Make sure that the temperature at the selected location is within the operating temperature range of the transmitter (see Standard Specifications in Appendix A).

Enter the parameters of the pipe and of the medium. After that, the transducers must be mounted and positionned. Measurement can then be started.

5.1 Selection of the Measuring Point

The correct selection of the measuring point is crucial for achieving reliable measurements and a high accuracy. Basically, measurement must take place on a pipe

- in which sound can propagate (see section 5.1.1)
- and in which a fully developed axi-symmetrical flow profile is observed (see section 5.1.2).

The correct positioning of the transducers is an essential condition for error-free measurement. It guarantees that the sound signal will be received under optimal conditions and evaluated correctly. However, because of the variety of applications and the different factors influencing measurement, there can be no standard solution for the positioning of the transducers. The correct position of the transducers will be influenced by the following factors:

- the diameter, material, lining, wall thickness and form of the pipe
- the medium flowing in the pipe
- the presence of gas bubbles in the medium.

Avoid the locations described in section 5.1.3.
Make sure that the temperature at the selected location is within the operating temperature range of the transducers (see Standard Specifications in Appendix A).

5.1.1 Acoustic Propagation

Acoustic propagation can be assumed when pipe and medium do not attenuate the sound so strongly that the signals get completely absorbed before reaching the second transducer. How strong the sound attenuation is in a specific system depends on:

- the kinematic viscosity of the liquid,
- the proportion of gas bubbles and solid particles in the liquid,
- the presence of deposits on the inner pipe wall,
- the wall material.

Make sure that following conditions are respected at the measuring point:

- the pipe is always filled
- no material deposits are building
- no bubbles accumulate (even bubble-free liquids can form gas pockets at places where the liquid expands, e.g. especially behind pumps and where the cross-sectional area of the pipe extends considerably).

5.1.2 Undisturbed Flow Profile

Many flow elements (elbows, slide valves, valves, pumps, T-sections, reducers, diffusers, etc.) distort the flow profile in their vicinity. The axi-symmetrical flow profile needed for correct measurement is no longer given. A careful selection of the measuring point makes it possible to reduce the impact of disturbance sources.

It is most important that the measuring point is chosen at a sufficient distance from any disturbance sources. Only then can it be assumed that the flow profile in the pipe is fully developed.

However, US300PM will give you meaningful measuring results even under non-ideal measuring conditions, with a liquid containing a certain proportion of gas bubbles or solid particles or if the recommended distances to disturbance sources can not be observed for practical reasons for example.

Examples

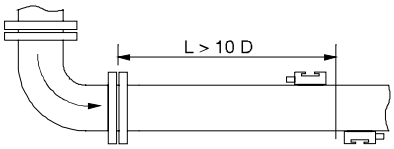
In the following examples, recommended straight inlet and outlet pipe lengths are given for different types of flow disturbance sources to assist you in selecting the correct measuring point.

(D = Nominal pipe diameter at measuring point, L = Recommended distance)

Disturbance source: 90 °-elbow

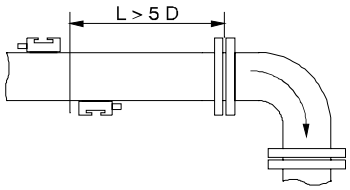
Inlet

L ≥ 10 D



Outlet

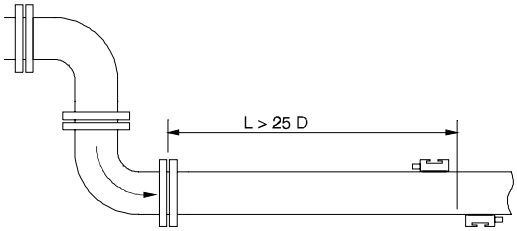
L ≥ 5 D



Disturbance source: 2 x 90 °-elbows in one plane

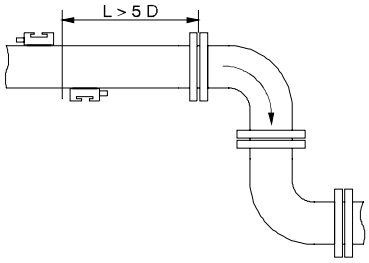
Inlet

L ≥ 25 D



Outlet

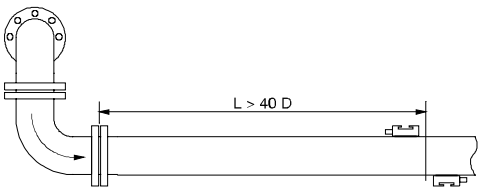
L ≥ 5 D



Disturbance source: 2 x 90 °-elbows in different planes

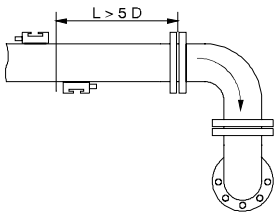
Inlet

L ≥ 40 D



Outlet

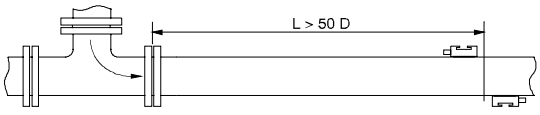
L ≥ 5 D



Disturbance source: T-section

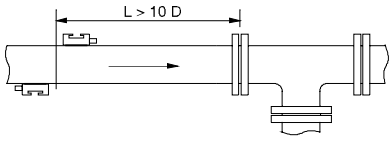
Inlet

L ≥ 50 D



Outlet

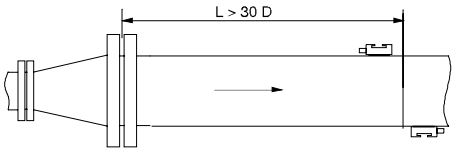
L ≥ 10 D



Disturbance source: diffuser

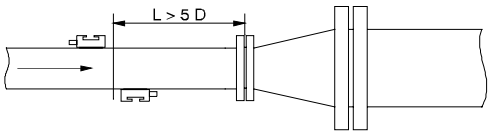
Inlet

L ≥ 30 D



Outlet

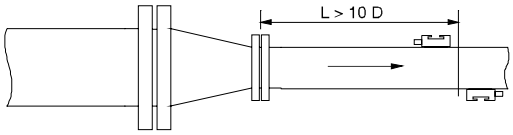
L ≥ 5 D



Disturbance source: reducer

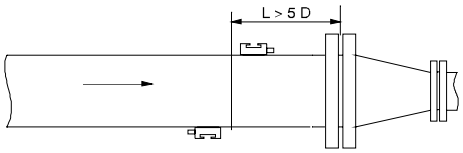
Inlet

L ≥ 10 D



Outlet

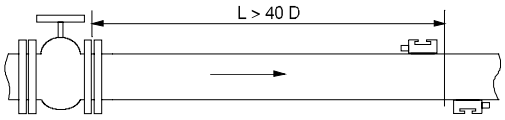
L ≥ 5 D



Disturbance source: valve

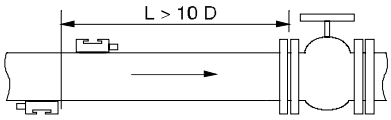
Inlet

L ≥ 40 D



Outlet

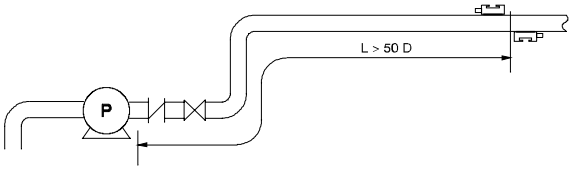
L ≥ 10 D



Disturbance source: pump

Inlet

L ≥ 50 D



5.1.3 Points to Avoid

Try to avoid measuring locations:

- in the vicinity of deformations and defects of the pipe
- or in the vicinity of weldings.

Avoid locations where deposits are building in the pipe.

Respect the recommandations given below.

For an horizontal pipe

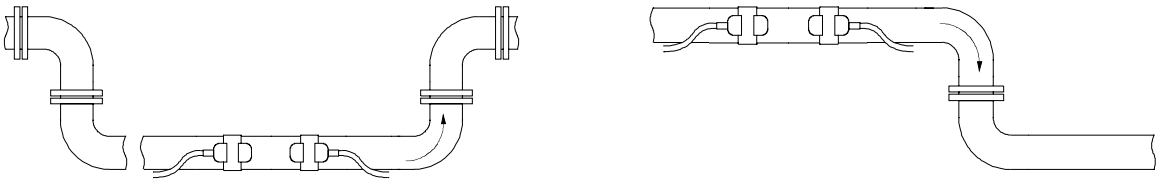
Select a location where the transducers can be mounted on the side of the pipe, so that the sound waves emitted by the transducers propagate horizontally in the pipe. Thus, the solid particles deposited on the bottom of the pipe and the gas pockets developing at the top won't influence the propagation of the signal.

Correct **Incorrect**

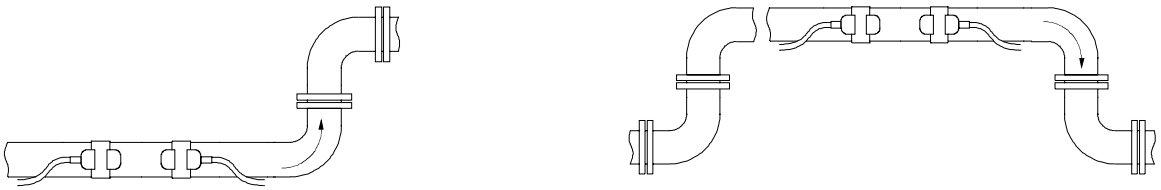
For a free inlet or outlet pipe section

Select the measuring point at a location where the pipe cannot run empty.

Correct **Disadvantageous**



Correct **Disadvantageous**



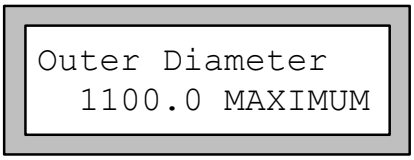
For a vertical pipe

Select the measuring point at a location where the liquid flows upward. The pipe must be completely filled.

Correct Incorrect

5.2 Input of the Parameters

Next step is the input of the parameters of the pipe and of the medium. They must be entered separately for every available measuring channel. The entered parameters can be modified at any time later by calling the program branch `PARAMETER` again.



The values that can be given to the parameters of pipe and medium are limited by the characteristics of transmitter and transducers. US300PM will warn you the entered values do not respect these limits (MINIMUM and MAXIMUM plausibility check).

In this example, the entered outer diameter was too big, so that US300PM displays the maximal value for this parameter (1100.0 mm in the case of transducers for medium-sized pipes and a pipe with a wall thickness of 50 mm).

5.3 Input of the Parameters of the Pipe

Note:	It is recommended to connect the transducers to the flowmeter **before** turning the flowmeter on.

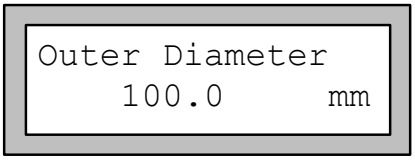
Connect the transducers to the flowmeter if they are not already connected. Turn the flowmeter on.

In the main menu, select the program branch PARAMETER and press **ENTER**.

Select the channel for which you want to set the parameters (⇳) and press **ENTER**.

If the display PARAMETER FROM appears at this point, at least a parameter record has been stored and can be recalled now. A parameter record is a set of all the data required to perform a certain measuring task: the pipe parameters, medium parameters and output options. You can create a parameter record for each of your measuring tasks. For more information on this subject, see chapter 9.

5.3.1 Pipe Outer Diameter / Circumference

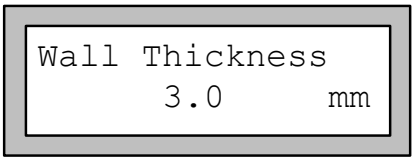


Enter the outer diameter of the pipe.

Confirm your entry or the displayed value by pressing **ENTER**.

It is possible to change this menu in order to enter the pipe circumference instead of the diameter. This setting is coldstart resistant and can be made in the program branch SPECIAL FUNCTION. See section 11.2.1.

5.3.2 Wall Thickness

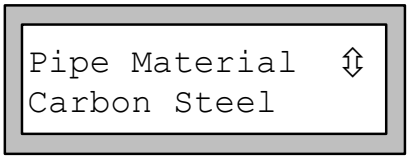


Enter the pipe wall thickness. The range of possible values depends on the transducer specifications. Default value for this parameter is 3.0 mm. Press **ENTER** to confirm your entry.

Attention!	US300PM calculates the inner diameter (outer diameter - 2 x wall thickness) and checks if this value is within the specified inner diameter range for the transducers used. An error message is displayed if this is not the case.

5.3.3 Pipe Material

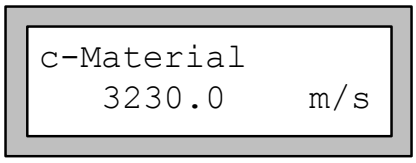
The pipe material now has to be entered in order to determine its sound velocity. The sound velocities of the materials of the selection list are already programmed in the instrument. When the pipe material is selected, US300PM sets the sound velocity automatically.



Select the pipe material (⇳) in the pipe material selection list. If the correct material is not listed, select the entry OTHER MATERIAL.

Confirm by pressing **ENTER**.

(It is possible to select which materials are to be displayed in the material selection list. See section 10.1).



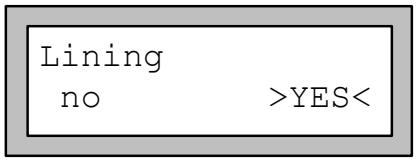
If you have selected OTHER MATERIAL, US300PM requests the entry of the sound velocity. Enter the sound velocity of the pipe material. Values between 600.0 and 6553.5 m/s are possible. Confirm by pressing **ENTER**.

(Table 1 of Appendix B gives the sound velocity of some selected materials.)

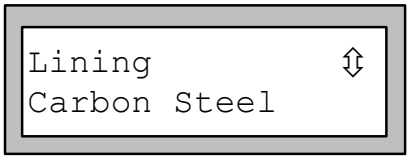
Important!	Enter here that sound velocity of the material (longitudinal velocity or transversal velocity) which is nearer to 2500 m/s.

Note:	The longitudinal sound velocity of the material can be measured with US300PM. See chapter 12.

5.3.4 Pipe Lining



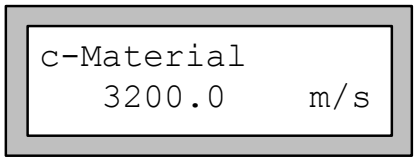
The instrument asks if the pipe is fitted with lining material or not. If YES, the following subdisplay group will be shown. If NO, US300PM will ask for the next parameter (section 5.3.5).



Select the lining material (⇳) or the entry OTHER MATERIAL if the lining material is not listed.

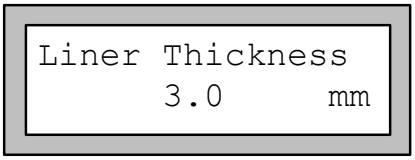
Confirm by pressing **ENTER**.

(It is possible to select which materials are to be displayed in the material selection list. See section 10.1).



If you have selected OTHER MATERIAL, US300PM requests the entry of the sound velocity. Enter the sound velocity for the lining material. Values between 600 and 6553.5 m/s are possible. Confirm by pressing **ENTER**.

(Table 1 in Appendix B gives the sound velocity of some selected materials.)

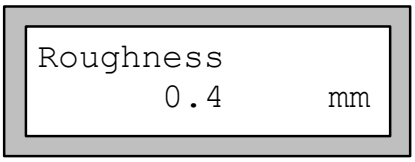


Enter the pipe liner thickness. Default value for this parameter is 3.0 mm. Confirm by pressing **ENTER**.

Attention!	US300PM checks the correlation between the entered outer diameter, the pipe wall and liner thickness. The inner diameter (outer diameter - 2 x wall thickness - 2 x liner thickness) should be within the specified inner diameter range for the transducers used. An error message is displayed if this is not the case.

5.3.5 Pipe Roughness

The roughness of the inner pipe wall influences the flow profile of the liquid and is used for the calculation of the profile correction factor. In most cases, the pipe roughness cannot be exactly determined, but must be estimated. For your convenience, we have compiled a list of roughness factors for a number of materials, based on experience and measurements (Table 2 in Appendix B). The display ROUGHNESS requests the input of a value for the selected pipe or lining material:



Change the suggested value according to the condition of the inner pipe wall. Default value of this parameter is 0.1 mm.

Confirm by pressing **ENTER**.

Note:	Only roughness values between 0.0 and 5.0 mm are allowed.

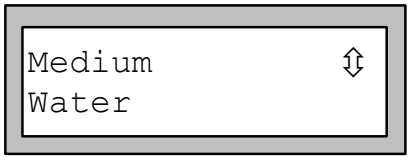
5.4 Input of the Parameters of the Medium

After you have finished entering the pipe parameters, US300PM asks for the medium parameters.

The medium parameters required for measurement are:

- the minimum and maximum sound velocity for the medium,
- the kinematic viscosity of the medium,
- the density of the medium (only if the output option MASS FLOW is activated),
- the temperature of the medium.

Table 3 in Appendix B gives an overview of pre-programmed parameters for those media which are often used.



Select the medium (⇳) or the entry OTHER MEDIUM if the medium you want to measure is not listed.

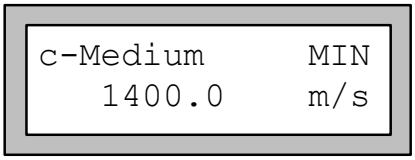
Confirm by pressing **ENTER**.

(It is possible to select which media are to be displayed in the medium selection list. See section 10.1).

If the medium has been selected, US300PM jumps straight to the display for entering the medium temperature (section 5.4.4). If you have selected OTHER MEDIUM, US300PM requests the entry of the minimal and maximal sound velocity, the kinematic viscosity and the density of the medium.

5.4.1 Sound Velocity

US300PM uses the sound velocity of the medium for the calculation of the distance between the transducers at the beginning of the measurement. As the sound velocity depends on the composition and the temperature of the medium, a range of possible values for the sound velocity must be entered.



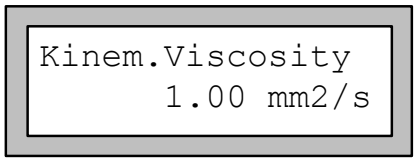
Enter the minimum and maximum values of the sound velocity for the medium you want to measure (in m/s).

Confirm your entries by pressing **ENTER**.

Note:	US300PM accepts sound velocities between 800.0 and 3500.0 m/s .

5.4.2 Kinematic Viscosity

The kinematic viscosity influences the flow profile of the liquid. US300PM uses the entered value of the kinematic viscosity as well as other parameters for the profile correction.



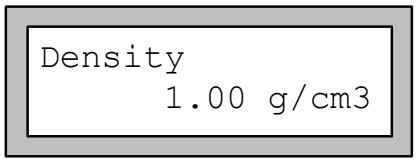
Enter the kinematic viscosity of the medium. Values between 0.01 and 30,000.00 mm^2/s are accepted.

Confirm by pressing **ENTER**.

5.4.3 Density

The input of the density of the medium is only necessary when mass flow has been selected as an output option (see chapter 6.1).

Note:	Mass flow is not measured directly. US300PM obtains the result for mass flow by multiplying volume flow with the density value which has been entered.

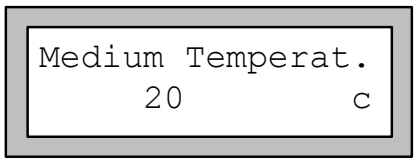


Enter the density of the medium. Values between 0.10 and 20.00 g/cm^3 are accepted.

Confirm your entry or the displayed value by pressing **ENTER**.

5.4.4 Medium Temperature

US300PM needs the medium temperature for the calculation of the distance between the transducers (distance suggested at the beginning of measurement). US300PM also uses the temperature of the medium for correcting the sound velocity and the viscosity which both depend on temperature.



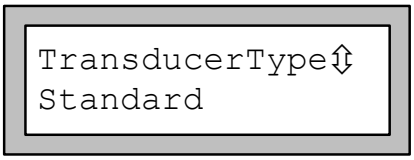
Enter the medium temperature. The value must be within the operating range of the transducer. The default value is 20°C.

Confirm by pressing **ENTER**.

Note:	The range of possible medium temperature depends on the operating range of the selected transducers.

5.4.5 Transducer Parameters

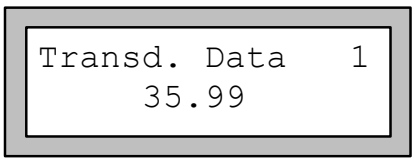
If no transducers are connected, if you have connected special transducers which US300PM cannot automatically recognize, or if the connected transducers are defective, following display will appear at the end of parameter input:



Select STANDARD to work with standard transducer parameters or SPECIAL VERSION to edit the transducer parameters (manufacturer's data must be available).

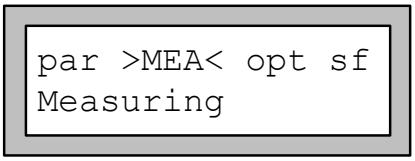
Confirm by pressing **ENTER**.

Attention!	Yokogawa cannot guarantee for the precision of values obtained when working with standard parameters. Measurement might be impossible.

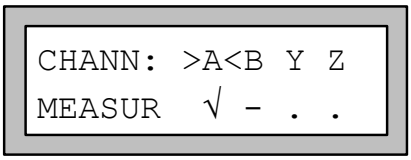


If you have selected SPECIAL VERSION, US300PM will ask for the transducer data. Enter the value of the 6 transducer parameters as given by the manufacturer, confirming each entry by pressing **ENTER**.

5.5 Selection of the Measuring Channels



In the main menu, select the program branch MEASURING, then press **ENTER**.



In the first display of the program branch MEASURING, activate the channels on which you want to measure and deactivate the others.

"√" means that the measuring channel is activated, "–" that the measuring channel is deactivated and "•" that the measuring channel cannot be activated (you did not enter parameters for that channel).

Use the keys Q- **4** and **6** Q+ to select a measuring channel.

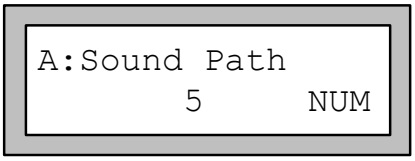
Press key Q_{ON} **8** to activate or deactivate the selected channel.

A deactivated channel will be ignored during the measurement. All parameters entered for this channel will remain unchanged.

When all channels have been configurated, confirm this by pressing **ENTER**.

Note:	A measuring channel cannot be activated if its parameters are not valid (for example if the program branch PARAMETER for the respective measuring channel has not been worked through completely).

5.6 Selection of the Sound Path Factor



Enter the number of transit paths of the ultrasonic waves through the medium in the pipe.

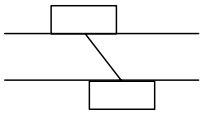
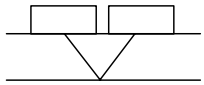
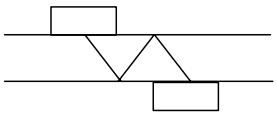
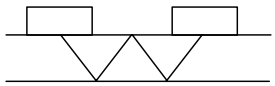
Confirm by pressing **ENTER**.

A sound path factor of "0" (zero) is nonsense in terms of physics.

An **odd** number of transits (diagonal mode) requires mounting of the transducers on opposite sides of the pipe (see illustration below).

An **even** number of transits (reflection mode) requires mounting of the transducers on the same side of the pipe (see illustration below).

An increased number of transit path means increased accuracy of the measurement. However, the increased transit distance also leads to a higher attenuation of the signal in the flowing medium. The reflections on the opposite pipe wall and eventual deposits on the inner pipe wall cause additional amplitude losses of the sound signal. Working with strongly attenuating medium flowing in a pipe which is also strongly attenuating and where deposits can be found on the inner pipe wall, it is possible that only one transit path is possible (after two transit paths, the amplitude of the signal is already insufficient for measuring).

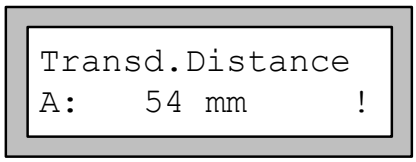
Transducer installation in diagonal mode		**Transducer installation in reflection mode**	
factor=number of transits	**sound path**	**factor=number of transits**	**sound path**
1		2	
3		4	
etc.		etc.	

Note:	Correct positioning of the transducer is easier for an even number of transit paths as for an odd number.

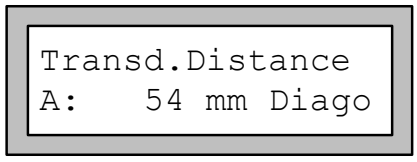
5.7 Mounting and Positioning of the Transducers

5.7.1 Distance between the Transducers

Once the number of transit paths has been entered, following display appears.



(Letter A = Measuring channel A)

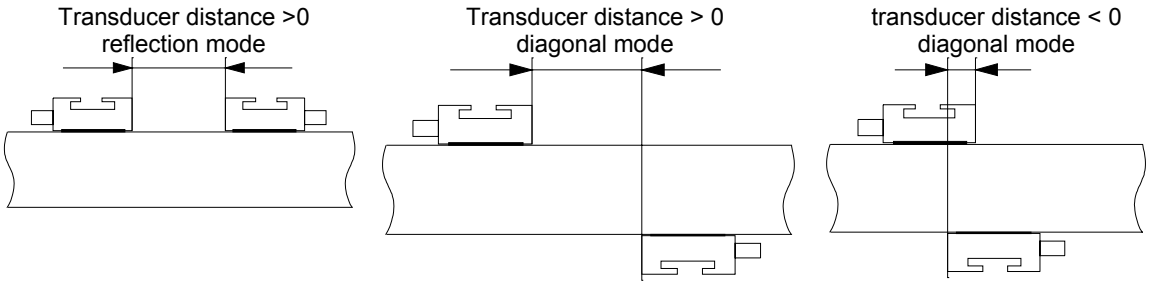


If you have entered the sound path factor numerically, 'Refle' (reflection) or 'Diago' (diagonal) appears behind 'mm'.

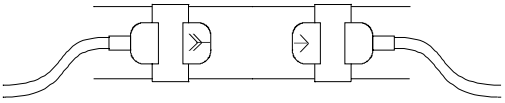
The display indicates at which distance from another the transducer should be mounted (here: 54 mm). The transducer distance given here is the distance between the inner edges of the transducers. For very small pipes, a negative transducer distance is possible, as illustrated below.

Note:	The accuracy of the distance suggested by US300PM depends on the accuracy of both the pipe and medium parameters entered.

For very small pipes, a negative transducer distance is possible, as illustrated in the following scheme:



5.7.2 Mounting of the Transducers

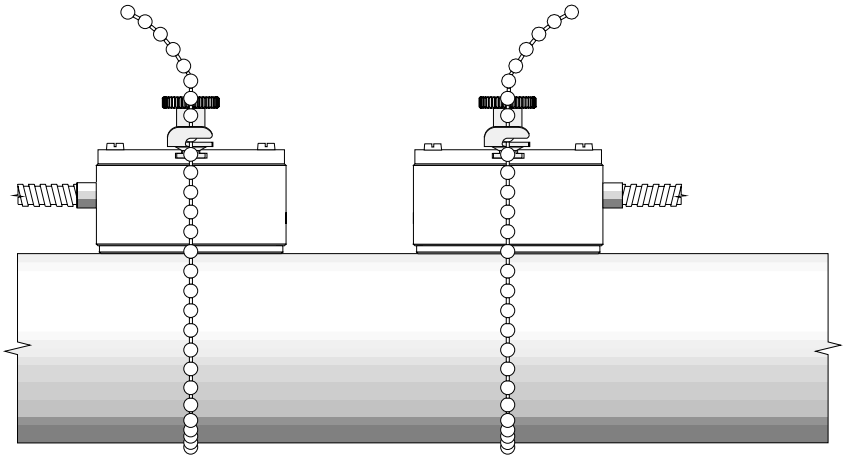


Always mount the transducers so that the front edges are opposite to each other. The engravings on the top of the transducers should form an arrow, as illustrated beside.

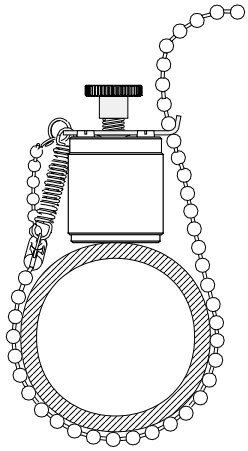
In order to obtain maximal acoustic contact between the pipe and the transducers, pay attention to the following points:

- Rust or other deposits absorb the sound signals! Clean the pipe at the emplacement where you plan to mount the transducers. Remove rust or loose paint. Grind off any thick layer of paint.
- Always apply a bead of acoustic coupling compound lengthwise down the center of the contact surface of the transducers.
- There should be no air or air pockets between transducer surface and pipe wall. Make sure that the mounting fixture applies the necessary pressure on the transducers.

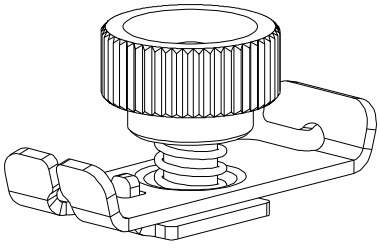
5.7.2.1 Mounting with Chains



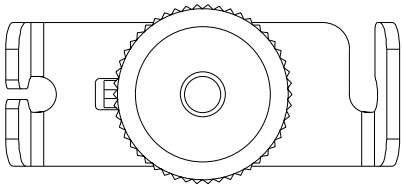
Side view of a pipe with fastened transducers



Sectional view of a pipe with fastened transducers



Top view of the retaining clip



Side view of the retaining clip

- Insert the retaining clip into the groove on the top of the transducer and secure it using the knurled screw.
- Apply some acoustic coupling compound to the contact surface of the transducer. Place the transducer on the pipe and press it firmly.
- Take the spring end of the chain in the hand and insert the ball at its extremity in the vertical slot of the retaining clip. Lay the chain around the pipe (if the chain is not long enough, refer to section 5.7.2.2). When mounting the transducers on a vertical pipe and US300PM is placed lower than the pipe, it is recommended to slip the cable of the upper transducer under the chain in order to free it from mechanical strain.
- Pull the chain firmly and insert it in the lateral slot of the retaining clip. There should be no air or air pockets between transducer surface and pipe wall.
- Mount the second transducer in the same way. Using a ruler, adjust the transducer distance to the distance suggested by US300PM.

5.7.2.2 Extension of the Ball Chain

- Take the fastening clip of the extension between thumb and index finger.
- Hold the loose end of the ball chain in your other hand.
- Put the last ball part into the bigger opening of the fastening clip. Press the chain bridge through the free slot in order to move the last ball inside the fastening clip.

(Reverse the sequence of these operations to separate the extension again.)

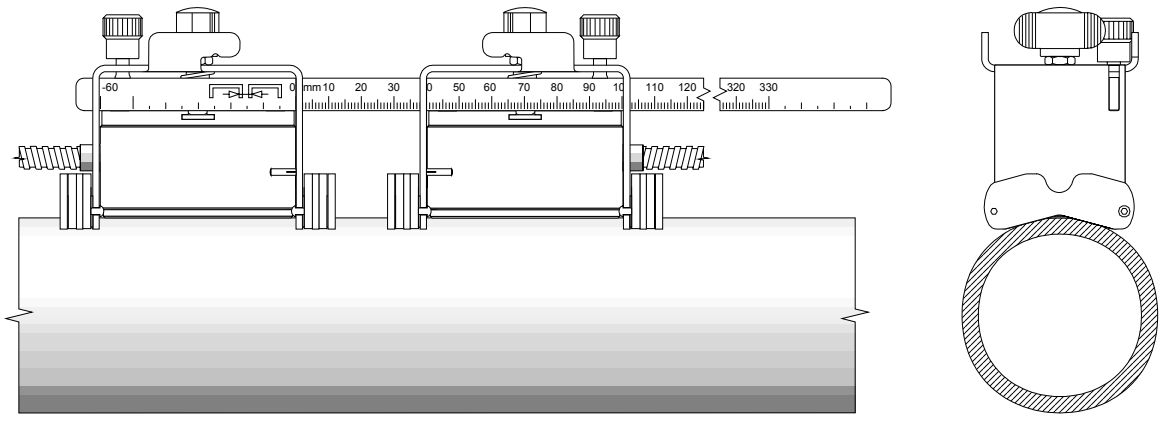
5.7.2.3 Chain Repair Set

- The fastening clips of the chain repair set are for connecting (repairing) broken chain elements or making the chain longer.
- The clasps of the repair set are for the coupling of the spring with the chain if the integrated anchor is missing.

5.7.2.4 Mounting with Fixtures

Note:	If the transducers are mounted only with the mounting fixtures, they might slip or fall down. It is recommended to fasten the mounting fixtures with chains.

- Insert the transducers in the mounting fixtures. Turn the screw on top of the fixtures by 90° in order to engage and lock its extremity in the groove of the inserted transducer.
- Apply acoustic coupling compound to the contact surface of the transducers.
- Insert the ruler in the lateral slots of the fixtures (see drawing below). Adjust the transducer distance to the distance suggested by US300PM and fix the transducers with the small plastic screws on the transducer cable side of the fixture.

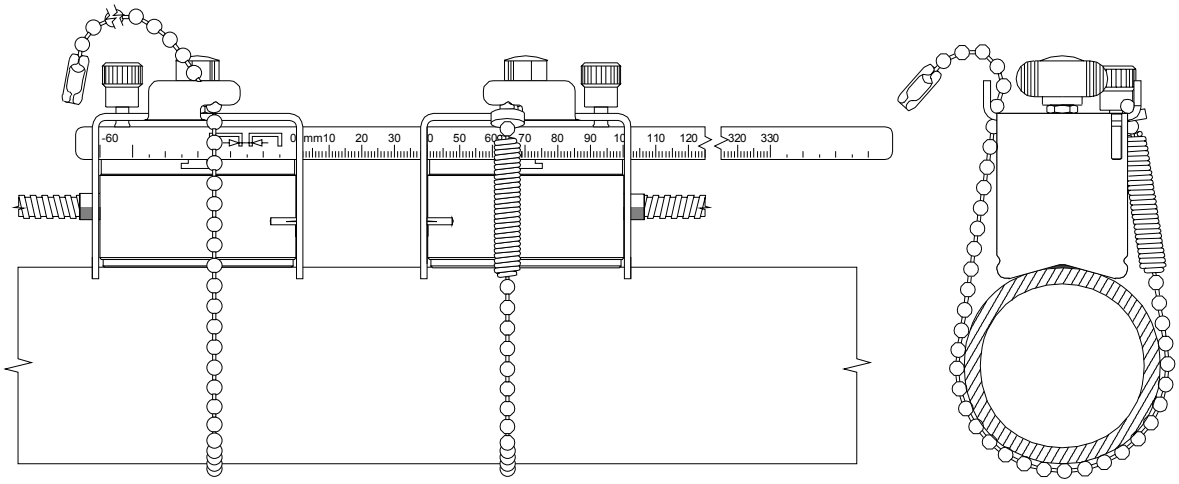


For the magnetic fixtures:

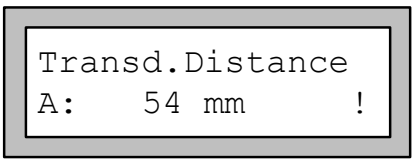
- Place the fixtures/ruler assembly on the pipe at the measuring point. There should be no air or air pockets between transducer surface and pipe wall.
- Adjust transducer distance again.

For the standard fixtures:

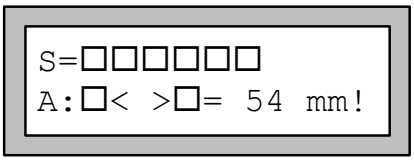
- Place the fixtures/ruler assembly on the pipe at the measuring point.
- Take the spring end of one of the ball chains, insert the last ball in the slot on the top of one of the runner.
- Lay the chain around the pipe (if the chain is not long enough, refer to section 5.7.2.2). When mounting the transducers on a vertical pipe and US300PM is placed lower than the pipe, it is recommended to slip the cable of the upper transducer under the chain in order to free it from mechanical strain.
- Pull the chain firmly and insert it in the second slot on the top of the runner. There should be no air or air pockets between transducer surface and pipe wall.
- Fix the other transducer in the same way. Adjust transducer distance again.



5.7.3 Positioning of the Transducers



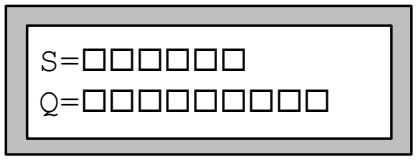
When the transducers are mounted, confirm the transducer distance by pressing **ENTER**. The positioning procedure of the transducers is started.



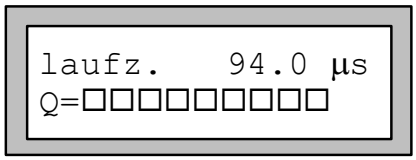
A bar graph ("S=") informs you of the amplitude of the received signal.

Adjust the transducers by moving them slightly in order to obtain a maximal length of the bar graph.

If the signal received by the channel is sufficient for measurement, the SIGNAL LED shows green; if not, it shows red. In the last case, adjust the transducers by moving them slightly until the SIGNAL LED shows green.



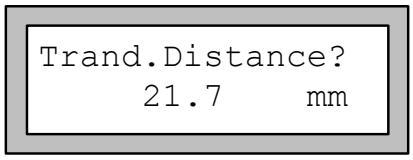
Press key **3** DISP to switch on the lower line between the display of the transducer distance and the bar graph of the quality of the signal ("Q="). If the signal is not sufficient for measurement, UNDEF is displayed.



Press key DISP **9** to scroll on the upper line between the display of the bar graph of the signal amplitude ("S="), the bar graph of the quality of the signal ("Q=") and the display of the transit time ("laufz.") in microseconds.

Attention!	It is important for the flow measurement that the signal maximum with the shortest transducer distance (shortest transit time) is used. However, this signal maximum should not deviate from the suggested distance by more than ± 0.5 cm. In case of bigger deviations, check if the entered parameter inputs are correct or repeat measurement at a different location on the pipe.

Renew the film of acoustic coupling compound if necessary.



After the precise positioning of the transducers, the suggested transducer distance is displayed again (here: 21.7 mm).

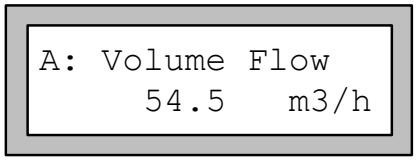
Enter the current - precise - transducer distance and press **ENTER** or just confirm the displayed value by pressing **ENTER**.

It is possible to have US300PM remind you of the last entered precise transducer distance in this display. See section 11.2.4.

The precise transducer distance is essential for an exact measurement of the sound velocity of the medium, see chapter 14.

5.8 Starting the Measurement

Repeat steps described in section 5.6 and 5.7 for all channels on which you want to measure. When the precise transducer distance has been entered for all these channels, the measurement will be automatically activated.



You can press **ENTER** to return to the bar graph display.

US300PM undertakes measurements on all activated measuring channels in a quasi parallel manner. The multiplexer switches every second between the activated channels to measure the flow. The SIGNAL LED of an activated channel flashes as the measurement takes place. All process outputs as well as the serial interface continuously get the measuring results of the assigned channel.

The results are displayed according to the actually selected output options (see chapter 6.1). Default setting is the display of volume flow rate in m^3/h.

Chapter 6 describes the selection of the values to be displayed and the setting of the output options. Advanced measuring functions are described in chapter 7.

5.9 Stopping the Measurement

You can stop the measurement on all activated measuring channels at any time by pressing **BRK**.

Attention!	Be careful not to interrupt an ongoing measurement by inadvertently pressing **BRK**!

5.10 Recognition of Flow Direction

The direction of flow in the pipe can be recognized with the help of the displayed "Volume Flow" in conjunction with the arrow formed by the engravings on the transducers:

The medium flows in direction of the arrow if the display shows a positive flow reading (example: 54.5 m^3/h).

The medium flows against the arrow direction if the display shows a negative flow reading (example: -54.5 m^3/h).

6 Displaying the Measured Values

The physical quantity to be measured and used for storage and output can be set in the OUTPUT OPTIONS program branch as described in section 6.1. Default display setting is that the designation of the quantity of measurement selected in the OUTPUT OPTIONS is displayed on the first line and its value on the second line. It is possible to temporary adapt the display to your requirements by selecting which quantity should be shown on the first and second line of the display (see section 6.3).

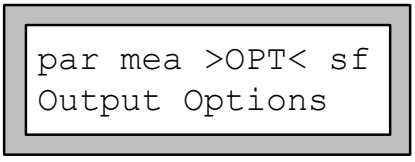
It is possible to have the measured values of only one selected channel displayed, or to switch between the activated channels every second (see section 6.2).

6.1 Selection of the Physical Quantity and of the Unit of Measurement

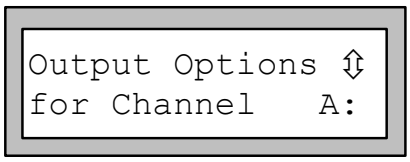
US300PM can measure the following quantities:

- volume flow rate
- mass flow rate
- flow velocity
- sound velocity of the medium

US300PM measures the flow velocity in the pipe directly. The volume flow is calculated by multiplying the flow velocity with the cross-sectional area of the pipe, the mass flow by multiplying the volume flow with the density of the medium. For the measurement of the sound velocity, the parameter record of the actual measuring channel (outer diameter, wall thickness) is used.

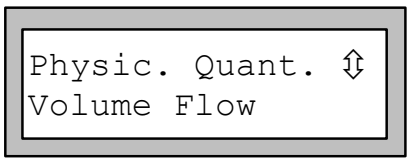


In the main menu, select the program branch OUTPUT OPTIONS.



Select the measuring channel for which you want to set the output options.

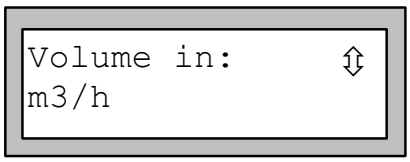
Confirm by pressing **ENTER**.



Select the desired quantity of measurement in the scroll list.

Confirm by pressing **ENTER**.

The selection of the physical quantity SOUND VELOCITY immediately ends the program branch OUTPUT OPTIONS, because during the measurement of the sound velocity the process outputs, serial interface and internal data memory do not operate. The measurement of the sound velocity is described in chapter 14.



For all quantities of measurement other than SOUND VELOCITY, a scroll list of the available measurement units is displayed (refer to Standard Specifications). The previously selected unit is shown on the second line. Select the unit of measurement in which you want to have the chosen physical quantity displayed and output.

Confirm by pressing **ENTER**.

You can now return to the main menu by pressing **BRK**. The next displays of the program branch OUTPUT OPTIONS are for the activation of the different output options (process outputs, data logger, output to a PC, etc...).

6.2 Toggling between the Channels

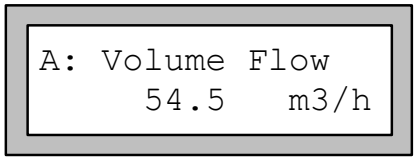
US300PM undertakes measurements on all activated measuring channels in a quasi parallel manner. The multiplexer switches every second between the activated channels to measure the flow. The SIGNAL LED of an activated channel flashes as the measurement takes place. All process outputs as well as the serial interface continuously get the measuring results of the assigned channels.

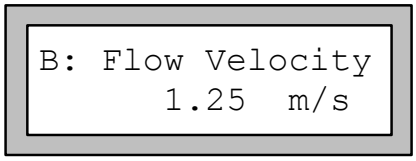
US300PM can display the measured values of the different channels in two different modes: AutoMux and HumanMux.

You can toggle between the AutoMux and HumanMux modes with key 1 MUX.

6.2.1 AutoMux Mode

In Auto-Mux mode, the display is synchronized with that channel where the measurement is actually taking place. This channel is displayed on the upper left corner of the display (A, B, ...):

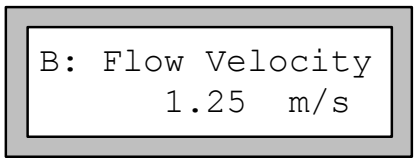




For this channel, US300PM displays the measured values as configurated in the OUTPUT OPTIONS program branch (see section 6.1).

6.2.2 HumanMux Mode

In HumanMux mode, US300PM displays the measured values for one measuring channel only. Measurement still takes place on all other activated channels - without display of the results.



US300PM shows the selected measuring channel on the upper left corner of the display (A, B, ...).

Press key NEXT 7 to select the next activated channel for displaying.

US300PM displays the measured values as configurated in the OUTPUT OPTIONS program branch (see section 6.1) for the selected channel.

6.3 Configuration of the Display

US300PM gives the option of displaying two of the measured values (one on each line of the display) and of configuring the display readings according to your requirements.

You can change the displayed values independently and without interfering with the ongoing measurement. The changes have no influence on the total counters, the storage of measured values, the operation of the process interfaces etc..

Following information can be displayed on the first line of the display:

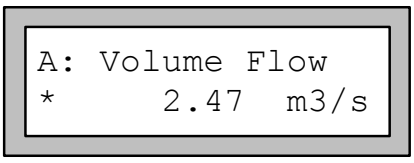
- Designation of the quantity of measurement actually being measured and recorded
- Totalizer values (if activated)
- the date and time at which the memory will be full
- the operating mode
- the transducer distance (see section 6.4)
- the reckoning function if activated
- the time remaining until the automatic stop of a programmed measurement
- the state of the alarms if any alarm output is activated and the display of the alarm's state is enabled (see section 15.6)
- the operating mode.

Use key DISP 9 to scroll through the different displays of the first line while measurement is going on.

Following information can be displayed on the second line in addition to the selected quantity of measurement:

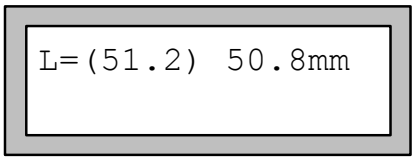
- Flow velocity
- Volume flow rate
- Mass flow rate

Use key 3 DISP to scroll through the different displays of the second line while measurement is going on.



The "*****"-character is a reminder that the shown value (in this case the volume flow) is not the selected physical quantity.

6.4 Transducer Distance



During measurement, it is possible to scroll to the display of the transducer distance by pressing the key DISP 9.

The actual optimal transducer distance is given first in parenthesis (here 51,2 mm), then the entered transducer distance (here: 50.8 mm). The optimal transducer distance might change during measurement due to temperature fluctuations for example. An eventual mispositioning of the transducers (here: -0,4 mm) will be internally compensated by US300PM.

Attention!	Never change the transducer distance during measurement, this would lead to false values of the sound velocity!

7 Advanced Measuring Functions

7.1 The Damping Factor

The damping factor is the integration time of the calculated gliding average value. Default value for the damping factor is 10 s (value for normal flow conditions). Strongly fluctuating readings caused by high flow dynamics require a larger damping factor.

Select the OUTPUT OPTIONS program branch of the channel for which you want to set the damping factor. Confirm this by pressing **ENTER**. Work yourself through the scroll list, confirming the already selected options by pressing **ENTER**, until you reach the DAMPING option.

Enter the necessary damping factor. Values between 1 and 100 s are accepted.

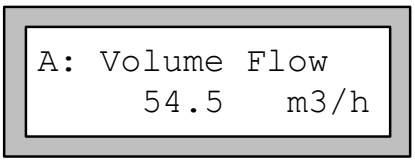
Confirm by pressing **ENTER**.

You can now return to the main menu by pressing **BRK**.

7.2 Flow Totalizers

US300PM has two built-in flow totalizers, one for totalizing in positive flow direction, the other for totalizing in negative flow direction.

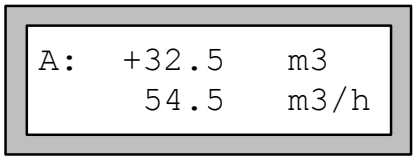
- US300PM totalizes the **volume** or the **mass** of medium passing through the pipe at the measuring point.
- The unit of measurement used for totalization corresponds to the volume or mass unit used in the quantity of measurement (see section 6.1).
- Every numerical value of the totalizer consists of up to 11 characters, with a maximum of 3 figures to the right of the decimal point.



The two built-in flow totalizers can be activated simultaneously in the VOLUME FLOW or MASS FLOW display during measurement.

To activate the flow totalizers:	Press key 8 (Q_{ON})
To have the totalizer for positive flow direction displayed:	Press key 6 ($Q+$)
To have the totalizer for negative flow direction displayed:	Press key 4 ($Q-$)
To reset the two flow totalizers to zero:	Press key 8 (Q_{ON}) when a totalizer is displayed.
To deactivate flow totalizing:	Press key 2 (Q_{OFF}) when a totalizer is displayed.

Attention!	The flow totalizers can only be activated for the measuring channel which measured values are actually displayed.



Once the totalizers are activated, the totalized value is shown on the first line of the display (here: the volume which has passed the measuring point in positive flow direction since the activation of the totalizers).

7.2.1 Settings

The behavior of the totalizer after a measurement has been interrupted can also be set in the program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ MEASURING.

In the MEASURING scroll list, select the QUANTITY RECALL option.

If you select ON, the previous numerical values of the totalizers are kept after restart of the measurement.

If you select OFF, the numerical values of the totalizers are reset to zero after restart of the measurement.

It is possible to store the value of the currently displayed totalizer only or one value for each flow direction. In the SPECIAL FUNCTION \ SYSTEM SETTINGS \ STORING program branch, select the QUANTITY STORAGE entry.

Select ONE if US300PM should only store the value of the displayed totalizer. Select BOTH to enable storage of the totalizer value in function of the flow direction.

Confirm by pressing **ENTER**.

Press **BRK** if you want to return to the main menu without changing the other settings of the data logger.

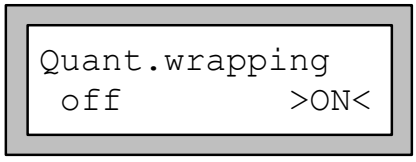
Note:	The selected totalizer storage mode will remain active even after a power failure or a cold start (INIT) has occurred.

7.2.2 Overflow of the Flow Totalizers

The flow totalizers can work in two different modes:

- Without overflow: The numerical value of the respective totalizer increases up to the internal limit of 10^{38}. The values are displayed as exponential numbers (±1.00000E10) if necessary. The totalizer can only be reset to zero manually.
- With overflow: The totalizer resets automatically to 0.000 as soon as ±9999999999 is reached (as for a water-clock).

The totalizer mode can be set in the program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ MEASURING. This setting is cold start resistant.



Select the QUANT. WRAPPING option.

Select ON to work with overflow, OFF to work without overflow.

This option will have no impact on the possibility to reset totalizers manually.

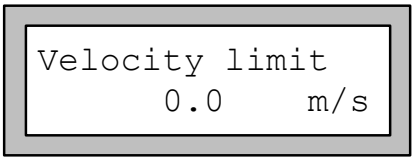
Note:	• The overflow of a totalizer influences all output channels, e.g. storage of measured values, serial online output, etc. • The output of sum of both totalizer (the throughput 'ΣQ') via a process output will not be valid after the first overflow (wrapping) of one of the respective totalizers. • An alarm output should be set to FUNC: QUANTITY and TYP: HOLD if you want it to signalize the overflow of a totalizer.

7.3 Upper Limit for Flow Velocities

A single outlier caused by heavily disturbed surroundings can appear in flow measured values. This will affect all measuring quantities derived from the flow measured values. Such outliers are unsuitable for integral quantities (pulse outputs, e.g.).

You can predefine an upper limit for the flow velocity. The measuring process will then ignore all measured flow velocities bigger than this limit and will mark them as outlier ("invalid measured value" or "measurement impossible").

The upper limit for the flow velocity can be set in program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ MEASURING. This setting is cold start resistant.



In program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ MEASURING, select the VELOCITY LIMIT option. Enter the upper velocity limit. Values between 0.1 and 25.5 m/s are accepted. Entering 0.0 switches off the test for outliers.

Confirm by pressing **ENTER**.

When the test is activated (velocity limit > 0.0 m/s), every measured flow velocity will be compared with the entered upper velocity limit. If the flow velocity is bigger than the limit:

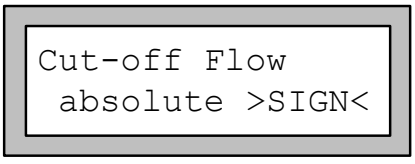
- The flow velocity will be marked "invalid"; the measuring quantity cannot be determined.
- The red SIGNAL LED is lighted.
- The display shows a '!' behind the unit of measurement. (In case of a 'normal' error, a '?' appears.)

Attention!	If the velocity limit is too small, measurement might be impossible (flow rate is always zero).

7.4 Cut-off Flow

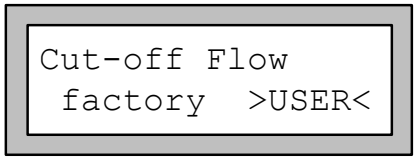
The cut-off flow function automatically sets all measured flow velocities falling below a certain value to 0 (zero). All values derived from this flow velocity are equally set to zero. Default cut-off value is 5 cm/s. Sign dependent and absolute cut-off values are possible. The largest cut-off value which can be set is 12.7 cm/s.

The cut-off value can be set in the program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ MEASURING. This setting is cold start resistant.



If you select ABSOLUTE, the user defined cut-off value will not depend on the sign identifying the direction of flow. There is only one limit to be set. The absolute value of the measured value will be compared with the cut-off value.

If you select SIGN, the user defined cut-off value will depend on the sign identifying the direction of flow. Two independent limits can be entered for positive and negative flow velocities.



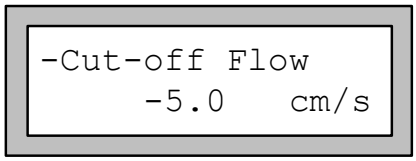
If you select FACTORY, US300PM will use the factory default setting of 5 cm/s for the cut-off value.

Select USER to define you own cut-off.

Confirm by pressing **ENTER**.

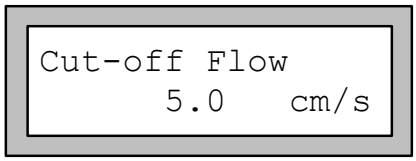
If you have previously selected CUT-OFF FLOW \ SIGN, two cut-off values must be entered:

Enter here the cut-off flow for positive measured values. When a positive value falls below this threshold, the flow velocity is set to 0 cm/s. All derived values are equally set to zero.



Enter here the cut-off flow for negative measured values. When a negative value rises above this threshold, the flow velocity is set to 0 cm/s. All derived values are equally set to zero.

If you have previously selected CUT-OFF FLOW \ ABSOLUTE, only one cut-off value has to be entered :



The limit comparison will be performed using the absolute numerical value of the measured flow velocity.

7.5 Reckoning Channels

7.5.1 Overview

In addition to the physically existing ultrasonic measuring channels (channels A and B), US300PM offers two virtual reckoning channels (channels Y and Z). These two 'virtual' channels allows you to combine numerically the measuring results of the two ultrasonic channels (measured value of channel A *minus* measured value of channel B for example).

The result of the numerical operation is the 'measured value' of the selected reckoning channel. This 'measured value' is equivalent to the measured values of a physical channel. In other words: Everything that can be done with the measured values of an ultrasonic measuring channel (totalization, online output, storing, process outputs, etc.) can also be done with the values furnished by a reckoning channel.

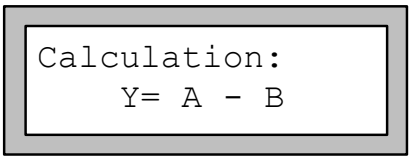
7.5.2 Characteristics of a Reckoning Channel

- The parameterization of a reckoning channel (program branch PARAMETER) differs from the parameterization of a physical channel. Instead of entering the parameters of the measuring point (pipe, medium), you have to decide which channels should be reckoned and how.
- The values of a reckoning channel cannot be attenuated. You have to set up the required damping factor separately for each of the two implied measuring channels (program branch OUTPUT OPTIONS).
- You can define two cut-off values for each reckoning channel. These cut-off values are not based on the flow velocity as for physical channels, but are defined in the unit of that quantity of measurement which was selected for the respective reckoning channel (program branch OUTPUT OPTIONS). During measurement, the reckoned values are compared with the set cut-off values and set to zero if necessary.

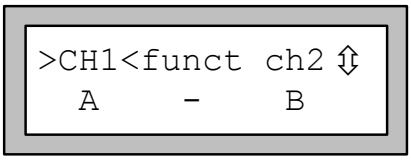
- A reckoning channel provides a valid measured value if both of the input channels provide valid measured values.

7.5.3 Parameterization of a Reckoning Channel

In the program branch PARAMETER, select a reckoning channel and confirm by pressing **ENTER**.



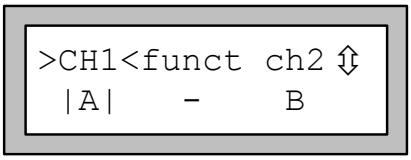
US300PM displays the actual reckoning function. Press any key to edit the function.



Three configuration scroll lists are displayed on the first line:

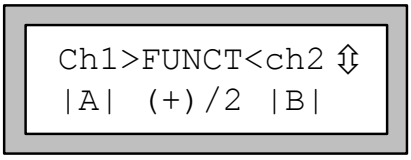
- CH1 for the selection of the first input channel,
- FUNCT for the selection of the reckoning function,
- CH2 for the selection of the second input channel.

Select a configuration scroll list using keys Q- **4** and **6** Q+.



The options of the selected list are displayed on the second line. Use the keys Q$_{ON}$ **8** and **2** Q$_{OFF}$ to scroll through this list.

All physical channels of the flowmeter as well as their absolute value can be selected as input channel.

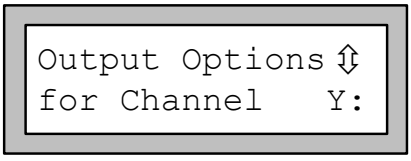


The following reckoning functions can be set:

Difference:	Y = CH1 – CH2
Sum:	Y = CH1 + CH2
(+)/2:	Y= (CH1 + CH2)/2

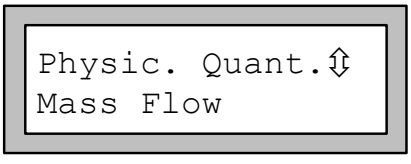
Confirm the reckoning function by pressing **ENTER**.

7.5.4 Output Options for a Reckoning Channel



Select a reckoning channel in the program branch OUTPUT OPTIONS.

Confirm by pressing **ENTER**.



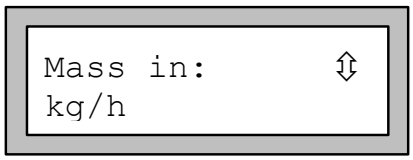
Select the physical quantity to be measured.

Confirm by pressing **ENTER**.

Make sure that the quantity of measurement that you select for the reckoning channel can be calculated out of the quantities of measurement of the two input channels selected for the reckoning function. The following table shows which combinations are possible.

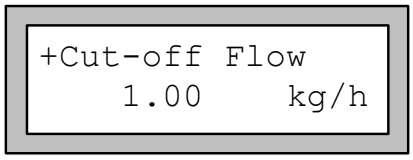
Physical quantity of the reckoning channel	Possible physical quantity of the first input channel (CH1)			Possible physical quantity of the second input channel (CH2)		
	Flow Velocity	Volume Flow	Mass Flow	Flow Velocity	Volume Flow	Mass Flow
Flow Velocity	X	X	X	X	X	X
Volume Flow		X	X		X	X
Mass Flow		X	X		X	X

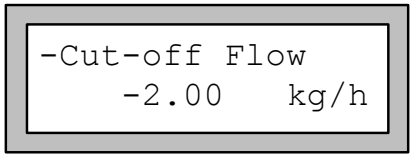
Example: *You wish to determine the difference of the volume flow rates of the channels A and B. The physical quantity of measurement of channel A can be the volume flow or the mass flow, but not the flow velocity. The physical quantity of measurement of channel B can also be the volume flow or the mass flow. The quantities of measurement of the two input channel do not have to be identical (channel A = mass flow; channel B = volume flow).*



Select the measuring units. Confirm by pressing **ENTER**.

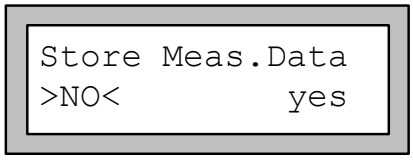
Two cut-off values can be defined for each reckoning channel. The cut-off value is defined in the unit selected for the quantity of measurement of the reckoning channel.





`+ CUT-OFF FLOW`: All positive reckoning values falling below this threshold will be set to 0.00.

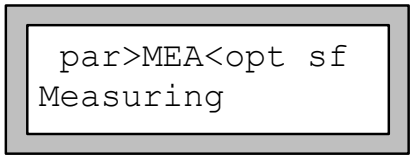
`- CUT-OFF FLOW`: All negative reckoning values rising above this threshold will be set to 0.00.



If you wish, you can now activate the storage of the measuring data of the reckoning channel. Confirm your selection by pressing **ENTER**.

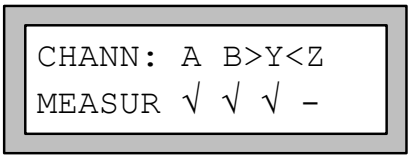
Note:	The values of a reckoning channel cannot be attenuated. Therefore, the dialogue for setting the damping does not appear.

7.5.5 Measuring with Reckoning Channels



Select the program branch `MEASURING`.

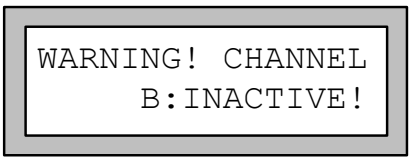
Confirm by pressing **ENTER**.



Activate the desired measuring channels. Reckoning channel can be activated and deactivated in the same way as physical channels (see section 5.5).

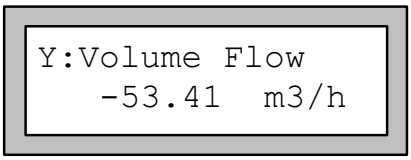
Confirm by pressing **ENTER**.

If you didn't activate any physical channel, US300PM immediately returns to the main menu.

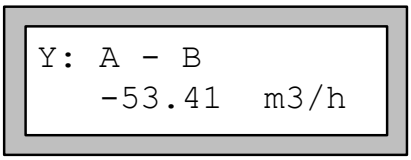


If you didn't activate a physical channel although you had selected it as input channel of an activated reckoning channel, this warning appears.

Proceed to positioning of the transducers for all activated physical channels, then start measurement.



When a reckoning channel has been activated, US300PM automatically switches to HumanMux mode at the beginning of the measurement (see section 6.2) and displays the values of the reckoning channel. If you switch to AutoMux mode, the measured values of the different physical channels (and not of the reckoning channels) will be displayed alternately.



To display the reckoning function, press on key DISP 9.

Press on key NEXT 7 to display the measuring results of the different channels.

8 Storage and Output of Measured Values

When measuring, US300PM can store or transmit to a PC the following data:

- Date
- Time
- Number of the measuring point
- Pipe parameters
- Medium parameters
- Transducer parameters
- Sound path (reflection or diagonal)
- Transducer distance
- Damping factor
- Storage rate
- Quantity of measurement
- Unit of measurement
- Measured values

The values of the activated process inputs and the totalizer values are also stored or transmitted automatically.

The measurement with the data logger function is described in section 8.1, the direct output of measured data to a PC (online output) in section 8.3. The stored measuring data can later be transmitted to a PC (offline output). This function is described in section 8.2.

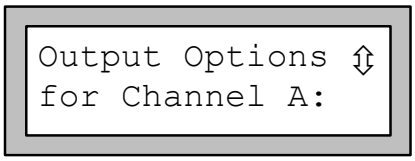
You will find information about the memory's capacity in section 8.8.

Note!	US300PM can store a maximum of 100 measuring data sets. The number of data sets that can be created depends on the total number of measured values stored in the precedent data sets. When all stored measured values have been deleted and a new measurement is started with only one quantity of measurement on one channel and no totalization, approx. 27 000 measured values can be stored in the data set of that measurement.

Note!	US300PM emits an acoustic signal every time a measured value is stored.

8.1 Measuring with the Data Logger Function

8.1.1 Activating/Deactivating the Data Logger Function



Select the OUTPUT OPTIONS program branch of the channel for which you want to activate the data logger function.

Confirm by pressing **ENTER**.

Select YES to activate the data logger function.

Confirm by pressing **ENTER**.

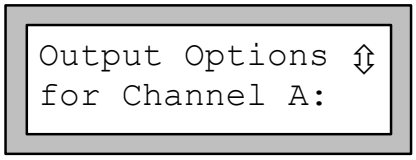
8.1.2 Setting the Storage Rate

The storage rate is the frequency at which US300PM outputs or stores the measured values. It is used for storing the measured data and for the serial output in online mode, and can be set for each measuring channel independently.

Note:	If you don't set the storage rate, the default rate or the last rate selected will be used.

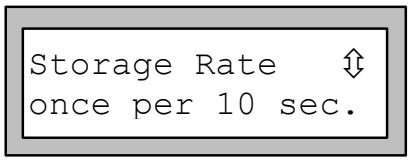
Note:	If whether the storage of measured values nor the serial output is activated, US300PM will omit the display group OUTPUT OPTIONS \ STORAGE RATE.

Note:	The storage interval in seconds should be at least equal to the number of activated measuring channels. (When 2 measuring channels are activated, the storage rate for a channel should be at least 2 seconds.)



Select the OUTPUT OPTIONS program branch of the channel for which you want to set the storage rate.

Confirm by pressing **ENTER**.

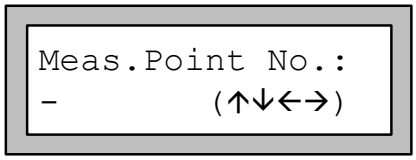


In the STORAGE RATE display, select one of the suggested storage rate. If the desired rate doesn't appear, select EXTRA, press **ENTER** and enter the storage rate manually. Values between 1 and 43200 seconds (12 hours) are possible.

Confirm by pressing **ENTER**.

8.1.3 Identification of the Measuring Point

At the beginning of measurement, US300PM will now ask you to identify the measuring point.



Enter the measuring point designation.

Confirm by pressing **ENTER**.

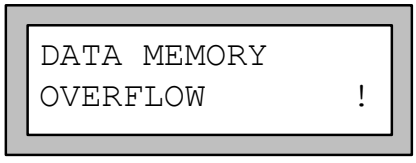
There are two input modes for the designation:

- the plain text mode (example: ´MS.PK20!´)
- and the numerical mode (decimal point and/or slash are also permitted, example: 18.05-06).

The input mode can be set in the program branch SPECIAL FUNCTION (see section 11.2.3). If arrows appear in the MEAS. POINT NO. display, the text input mode is activated. If not, only numbers, decimal point and dash can be entered.

When the measurement is started, US300PM will store the designation and the parameters of the measuring point together with the measured values.

8.1.4 Measurement



When measuring with activated data logger function, this error message will appear in case of a memory overflow. Confirm the message by pressing **ENTER**. The main menu will appear.

Attention:	US300PM will interrupt measurement if the internal memory is full and no other output option as storing has been activated! If another output option (serial output, process output, etc.) has been activated, US300PM won't interrupt measurement. Only the storage of measured data will be stopped. The error message F6 DATA MEMORY OVERFLOW appears periodically.

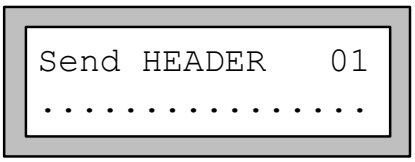
8.2 Offline Output of Measured Values

Offline output is the output of the measured values stored in the memory. The data can be sent:

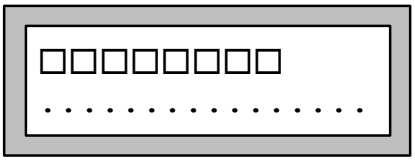
- to a printer connected with the serial interface of US300PM
- or as ASCII-file to a terminal program (e.g. *HyperTerminal* under *Windows*).

Select the SPECIAL FUNCTION program branch. Confirm this by pressing **ENTER**. Scroll through the list until you reach the PRINT MEAS VAL option.

Confirm your selection by pressing **ENTER**.



Connect US300PM to a PC or a serial printer using a RS2323 cable (USPA401 or equivalent). The output of the stored measured values starts when **ENTER** is pressed. This display indicates that the measured values are being transmitted.



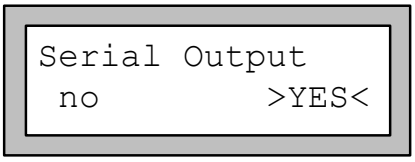
The displayed bar graph informs you of the progress of the data output.

US300PM transfers the data in the format described in section 8.4.

8.3 Online Output of Measured Values

The output of measured values to a PC or a serial printer may also be realized directly during measurement via serial interface.

Connect US300PM to a PC or a serial printer using a RS2323 cable (USPA401 or equivalent). Select the OUTPUT OPTIONS program branch. Confirm this by pressing **ENTER**. Select the channel for which you want to activate the serial interface. Work yourself through the scroll list, confirming the already selected options by pressing **ENTER**, until you reach the SERIAL OUTPUT option.



Select YES to activate the online output of the measured data via the serial interface. Confirm by pressing **ENTER**. If you don't set the storage rate (see section 8.1.2), the default rate or the last rate selected will be used.

US300PM transfers the measured data via serial interface with the protocol structure described in section 8.4 for the storage of measured data. An acoustic signal is emitted every time a measured value is transmitted.

8.4 Format of the Serial Output

The main measuring parameters are transmitted at the beginning of measurement, then the line "/DATA", followed by a line describing the contents of the columns of the table to come. The actual measured values are transmitted afterwards.

One data line is transmitted per storage interval (the storage rate can be set individually for each channel) and per activated measuring channel. The dummy line '???' will be transmitted in case no measured values are available for that storage interval.

Example: With a storage rate of 1 s, 10 dummy lines will be transmitted when the measurement is restarted after an interruption of 10 seconds for positioning the transducers.

US300PM can transmit the columns given in table below.

Column title	...	*MEASURE	Q_POS	Q_NEG	SSPEED	AMP
Column format		###000000.00	+00000000.00	-00000000.00		
Contents	Measuring channel	Quantity of measurement selected in OUTPUT OPTIONS	Value of the totalizer for the positive flow direction	Value of the totalizer for the negative flow direction	Sound velocity of the medium	Signal amplitude

The output of the sound velocity of the medium (SSPEED) and of the signal amplitude must be activated. Refer to section 8.7.3 and 8.7.4.

Online output (output during measurement)

In ONLINE mode, columns will be generated for all quantities which may be output during measurement. The columns Q_POS and Q_NEG will be empty if the totalizer function has not been activated. Since no totalizer can be enabled for the measuring quantity ‘flow velocity’, no columns for total values will be generated.

Offline output (output of stored measured values)

In OFFLINE mode, columns will only be generated if at least one measured value was stored in the respective data set. The columns Q_POS and Q_NEG are not generated if the totalizer function was not enabled.

Transmission parameter

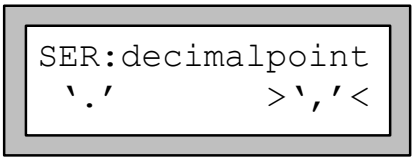
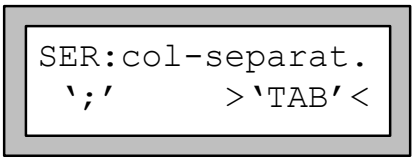
RS232: 9600 bits per second, 8 data bits, even parity, 2 stop bits, protocol (RTS/CTS)

US300PM sends CRLF-terminated ASCII.

Maximal line length: 255 characters.

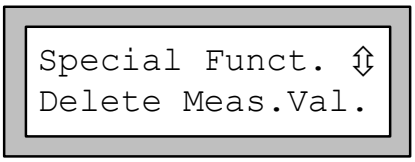
8.5 Serial Output Settings

Some format settings of the serial output can be edited in the program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ SERIAL TRANSMIS. This makes it possible for you to adapt the output depending on whether the data is being sent to a PC or transmitted to a serial printer. You can decide if spaces should be killed or not and decide which character should be used as decimal point and as column separator.

	TARGET: PC	TARGET: External printer
	ON is recommended, space characters will not be transmitted during the export of numerical values. In this way, the file size can be considerably reduced (i.e. shorter transmission time).	OFF is recommended as all measured values of a column will be printed one below the other.
	Which decimal separator is used for floating point variables (point or comma) depends on the country-specific settings for decimal numbers.	This setting is of a country-specific nature.
	Which character should be used for separating columns (semicolon or tabulator) depends on the requirements of the PC program. Generally, both separators can be used.	TAB increases the total width of a line depending on how the tabulator is set on the printer.

8.6 Deletion of Measured Values

With this special function, measured values stored in the memory of US300PM can be deleted. Select the SPECIAL FUNCTION program branch. Confirm this by pressing **ENTER**. Scroll through the list until you reach the DEL MEAS VAL option.



Confirm by pressing **ENTER**.

To avoid accidental deletion of data, US300PM asks for confirmation to make sure you really want to delete the stored measured values.
Confirm your choice by pressing **ENTER**.

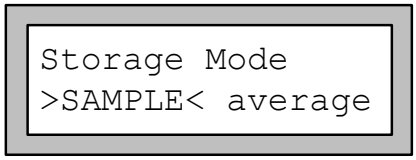
8.7 Settings of the Data Logger Function

Available options are the storage mode, storage of both totalizers, storage of the measured sound velocity and of the amplitude.

Select the SPECIAL FUNCTION program branch. Confirm this by pressing **ENTER**. Select the SYSTEM SETTINGS in the scroll list. Press **ENTER**. Select the STORING option in the scroll list.

Note:	All settings of the storage function are coldstart resistant.

8.7.1 Storage Mode



Select the storage mode (SAMPLE or AVERAGE).

In SAMPLE mode, US300PM uses the momentary measured value for storage and online output.

In AVERAGE mode, US300PM will use the calculated mean of the measured values of a storage interval for storage and online output.

Confirm your selection by pressing **ENTER**.

Further explanations

- The storage mode does not influence the continuously operating process interfaces (e.g. current output).
- In AVERAGE mode, all primary measuring quantities are averaged.
- In case no mean value could be calculated over the complete storage interval while the unit was in AVERAGE mode, the mean value for this interval will be marked as invalid. In the ASCII file with the stored measured values, ´???´ will appear for invalid mean values and the associated quantity of measurement. There will not be an indication of how many momentary measured values a valid mean value consists of.

8.7.2 Storage of the Totalizer

It is possible to store the value of the currently displayed totalizer only or one value for each flow direction. This setting is cold-start resistant.

In the SPECIAL FUNCTION \ SYSTEM SETTINGS \ STORING program branch, select the QUANTITY STORAGE entry.

Select ONE if US300PM should only store the displayed totalizer. Select BOTH to enable storage of the totalizer value in function of the flow direction.

Confirm by pressing **ENTER**.

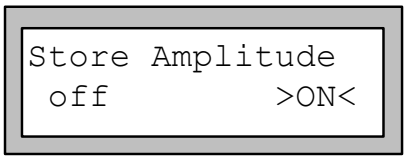
Further explanations

- US300PM will store the totalizers only if they are activated and the data logging function enabled.
- The storage of one totalizer halves the total number of measured values which can be internally logged, the storage of both totalizers quarters it.

  Example:
  In the program branch SPECIAL FUNCTION, US300PM shows that 10,000 measured values can still be stored. If the totalizers are activated and only one total value is logged, 3,333 data fields are available for storage. If both total values are saved, 2,000 data storage operations can be made.

8.7.3 Storage of the Amplitude

In the SPECIAL FUNCTION \ SYSTEM SETTINGS \ STORING program branch, select STORE AMPLITUDE entry.



If you select ON, US300PM will store the amplitude of the measured signal with the measured flow values when the storage of the measured values is activated.

Confirm by pressing **ENTER**.

8.7.4 Storage of the Sound Velocity of the Medium

In the SPECIAL FUNCTION \ SYSTEM SETTINGS \ STORING program branch, select the STORE C-MEDIUM entry.

If you select ON, US300PM will store the measured sound velocity of the medium with the measured flow values when the storage of the measured values is activated.

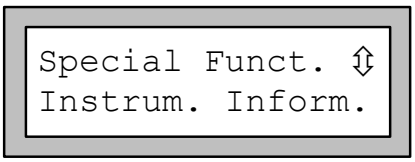
Confirm by pressing **ENTER**.

8.8 Available Memory

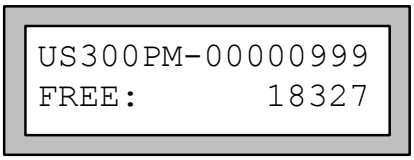
US300PM can store a maximum of 100 measuring data sets. The number of data sets that can be created depends on the total number of measured values stored in the precedent data sets.

When all stored measured values have been deleted and a new measurement is started with only one quantity of measurement on one channel and no totalization, approx. 27 000 measured values can be stored in the data set of that measurement.

Proceed as follows to find out how much memory is still available for storage.



Select SPECIAL FUNCTION \ INSTRUM. INFORM. Confirm by pressing **ENTER**.



The type designation and the factory number of your instrument are given on the first line.

The memory still available for data storage is given on the second line. Here: 18327 measured values can still be stored.

Press two times **ENTER** to return to the SPECIAL FUNCTION program branch.

9 Working with Parameter Records

Parameter records are data sets that contain all necessary information to perform a certain measurement task:

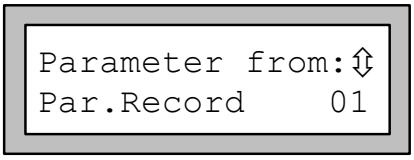
- the pipe parameters,
- the transducer parameters,
- the medium parameters
- and the output options.

Working with parameter records will make repeated measurement tasks easier and faster.

Parameter records can be created before each measurement and then stored using the program branch SPECIAL FUNCTION (see section 9.1). US300PM can store up to 14 different parameter records. If you wish to work with a stored parameter record, you need to load that record as "Current Record" (section 9.2).

The function **ParaPool** described in section 9.4 enables you to store up to 80 **short records** in an independent memory location under a specific name and ID number. A short records contains the main pipe and media parameters.

Note:	No records are stored in a new instrument. Records must be entered manually.



When records have been created, this display will always appear after selection of the PARAMETER program branch of a measuring channel.

If the ParaPool function is not activated, you can:

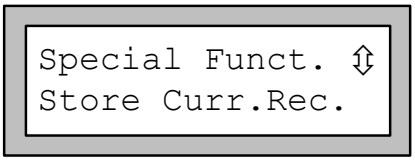
- select a parameter record to be loaded and edited or
- select CURRENT RECORD to edit the current parameters as usual.

If the ParaPool function is activated, you can:

- select a parameter record to be loaded and edited or
- select CURRENT RECORD to load a short record or
- select CURRENT RECORD and enter 0 (zero) or press key LF − to edit the current parameters as usual.

9.1 Saving Parameters in a Parameter Record

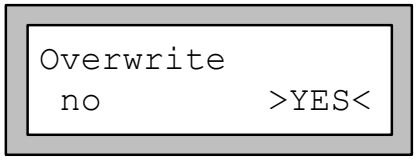
The parameters that you wish to save in a parameter record must first be entered as described in sections 5.3 and 5.4. Afterwards, they can be stored in a parameter record.



In the program branch SPECIAL FUNCTION, select the STORE CURRENT RECORD option.

Confirm by pressing **ENTER**.

The display STORE PAR. TO: appears and offers a choice of 14 parameter records (PAR.RECORD 01 to PAR.RECORD 14). Select a parameter record and confirm by pressing **ENTER**.



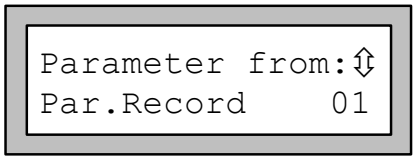
If parameters are already saved in the selected parameter record, US300PM asks if you want to overwrite them. Select YES to overwrite the parameters or NO to select another parameter record. Confirm by pressing **ENTER**.

9.2 Loading Parameter Records

Parameter records stored in memory can be easily be loaded and used for measurement.

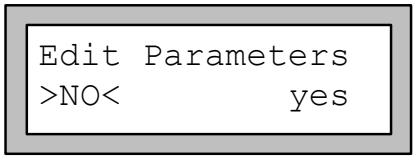
Select the program branch PARAMETER and press **ENTER**.

Select the channel on which you want to load a parameter record, then press **ENTER**.



In the next display, select the parameter record to be loaded.

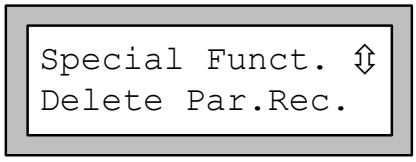
Confirm by pressing **ENTER**.



Select YES if you wish to edit the parameters of the selected record.

If you select NO, the main menu is displayed and you can start measuring.

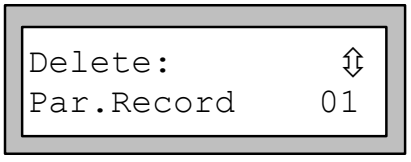
9.3 Deletion of Parameter Records



In the program branch SPECIAL FUNCTION, select the DELETE PAR. REC. option and press **ENTER**.

If no parameter records have been stored, an error message will appear.

Confirm by pressing **ENTER**



If parameter records have been stored, the display group DELETE appears. Scroll through the list of parameter records and select the one you wish to delete.

Confirm by pressing **ENTER**.

To avoid accidental deletion of data, US300PM asks for confirmation to make sure you really want to delete the selected parameter record.

Confirm your choice by pressing **ENTER**.

9.4 ParaPool Function

9.4.1 Features

The ParaPool function is characterized by the following features:

- The parameters of 80 different measuring points can be stored in the unit.
- Each of the 80 memory locations is identified by a 12-digit name.
- The stored data can be recalled by entering the identification number of the short record in the program branch PARAMETER.

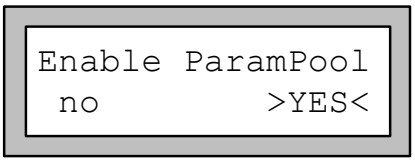
Each memory location contains following data for a measuring point:

- the name (12 digit ID of the measuring point/memory location),
- the outer diameter of the pipe,
- the wall thickness of the pipe,
- the pipe material,
- the lining material (if existing),
- the liner thickness (if existing),
- the inner roughness of the pipe,
- the medium flowing in the pipe,
- the approximate temperature of the medium.

Stored parameters can be transferred into the actual parameter record (see section 9.4.2). The parameters of the actual parameter record can be stored in ParaPool (see section 9.4.4).

9.4.2 Enabling/Disabling ParaPool

Enter HotCode **007021** to enable the ParaPool display.



In the ENABLE PARAMPOOL display, select YES to enable the ParaPool function, NO to disable it.

Confirm by pressing **ENTER**.

This setting is coldstart resistant.

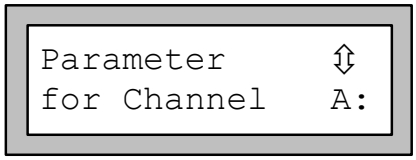
The measuring point parameters saved in ParaPool are not affected by the disabling of the ParaPool function. They will be ready for access as soon as the ParaPool function is enabled again.

9.4.3 Loading and Editing Short Records

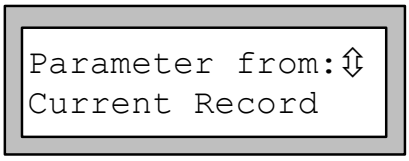
The parameters saved in short records must be loaded before they can be edited and used for measurement.

Select the program branch PARAMETER.

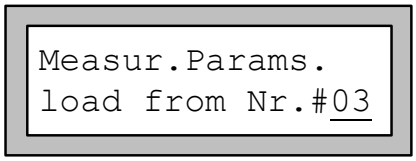
Confirm by pressing **ENTER**.



Select the channel on which you want to load a short record, then press **ENTER**.

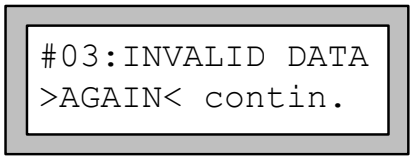


This display will only appear if parameter records have been stored. In this case, select CURRENT RECORD and press **ENTER**.



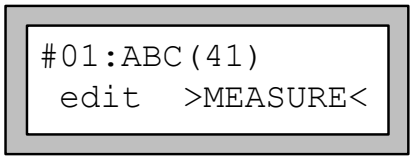
Enter the ID number (1 to 80) of the short record to be loaded.

Confirm by pressing **ENTER**.



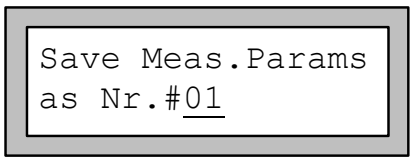
If this display appears, the selected short record is empty or contains invalid data. Select AGAIN to repeat the input of an identification number.

Confirm by pressing **ENTER**.



Select EDIT if you wish to edit the loaded parameters or select MEASURE to start measurement immediately.

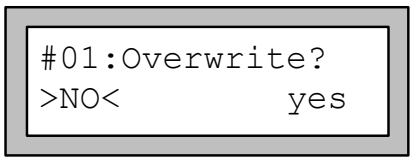
If you have selected EDIT, edit the parameters now as described in sections 5.3 and 5.4.



At the end of the edition of the loaded parameters, US300PM asks you under which ID number the edited parameters must be stored.

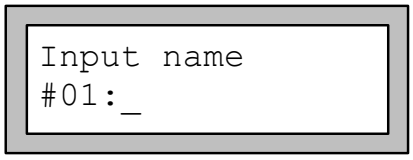
Enter an ID number (1 to 80).

Confirm by pressing **ENTER**.



If parameters are already saved in the selected short record, US300PM asks if you want to overwrite them. Select YES to overwrite the parameters or NO to enter another ID number.

Confirm by pressing **ENTER**.



Enter a name for the short record. (In the program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ DIALOGUES MENUS \ MEAS. POINT NO, you can choose if the name should be entered alphanumerically or as key sequence).

Confirm by pressing **ENTER**.

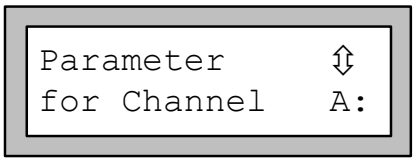
The parameters are saved under the selected ID number.

9.4.4 Saving Parameters in a Short Record

You can save the current parameters of a measuring channel in a short record, or load and edit the parameters of an already existing parameter record or short record and save them afterward in a short record.

Select the program branch PARAMETER.

Confirm by pressing **ENTER**.

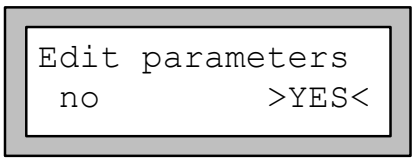


Select the channel which parameters you want to save in ParaPool.

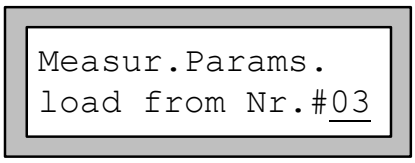
This display will only appear if parameter records have been stored.

If you want to load the parameters stored in a parameter record and save them in a short record, select that parameter record now.

Otherwise, select CURRENT RECORD and press **ENTER**.

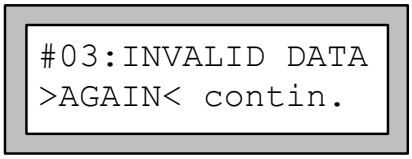


This display will appear if you have selected a parameter record in the previous step. Select YES to edit the loaded parameters before saving, or NO to save without edition.



If the parameters you want to save in a new record are already saved in a short record, enter the ID number of that record now, then press **ENTER**. The parameters of the selected record will be loaded.

If you wish to save the current parameters of the previously selected channel in a short record, enter 0 (zero) or press key LF. Press **ENTER** to confirm, then edit the current parameters.

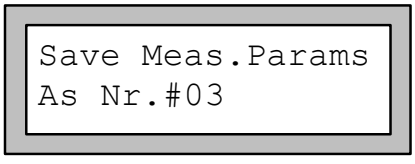


If this display appears, the selected short record is empty or contains invalid data.

Select AGAIN to repeat the input of an identification number.

If you select CONTIN., the current parameters are displayed for edition and can later be saved in a short record.

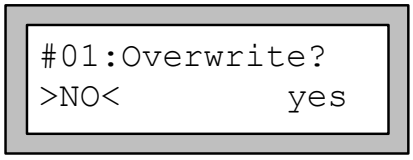
Confirm by pressing **ENTER**.



At the end of the edition of the loaded parameters, US300PM asks you under which ID number the edited parameters must be stored.

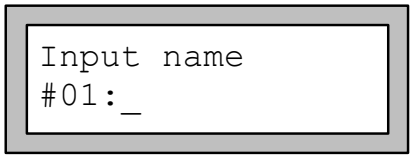
Enter an ID number (1 to 80).

Confirm by pressing **ENTER**.



If parameters are already saved in the selected short record, US300PM asks if you want to overwrite them. Select YES to overwrite the parameters or NO to enter another ID number.

Confirm by pressing **ENTER**.



Enter a name for the short record. (In the program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ DIALOGUES MENUS \ MEAS. POINT NO, you can choose if the name should be entered alpha-numerically or as key sequence).

Confirm by pressing **ENTER**.

The parameters are saved under the selected ID number.

10 Libraries

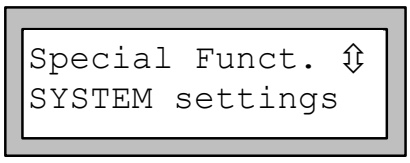
The internal data bank of the instrument contains the properties of more than 20 different materials (pipe material, lining) and more than 40 different media. It is possible to select the materials and fluids displayed in the selection lists of the program branch PARAMETER (pipe material, lining, medium). You can thus adapt the list to your specific measuring tasks and the shorter selection lists make your work more efficient (see section 10.1).

An integrated coefficient storage (user area) allows you to define new materials and media. The US300PM coefficient storage can be partitioned as you like. For more information about user materials and media, see section 10.2.

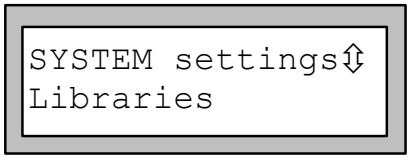
10.1 Editing the Selection Lists

The procedures for the edition of the material and of the media selection list are the same. We describe here the edition of the material selection list.

Note:	User materials and media are always displayed in the selection lists of the program branch PARAMETER.



In the program branch SPECIAL FUNCTION, select the option SYSTEM SETTINGS and press **ENTER**.



In the SYSTEM SETTINGS scroll list, select the option LIBRARIES and press **ENTER**.

Select MATERIAL LIST to edit the material selection list.

Select MEDIUM LIST to edit the medium selection list.
Select GO BACK to return to the SYSTEM SETTINGS.
Confirm you selection by pressing **ENTER**.

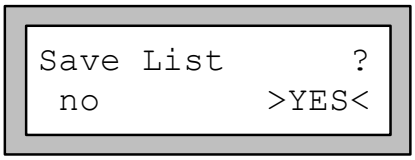
Select FACTORY if all materials/media of the internal data bank should appear in the selection lists. An already existing selection list will not be deleted but only deactivated.

Select USER to activate the user-defined selection list.

Confirm by pressing **ENTER**.

If USER has been selected, you now have the possibility to edit the selection list. The options of the scroll list are described in section 10.1.1 to 10.1.5.

After edition, select END OF EDIT and press **ENTER**.



Select YES to save all changes made in the selection list or NO to leave the edition menu without saving.

Confirm by pressing **ENTER**.

Note:	If you quit the edition menu with **BRK** before saving, all changes will be lost.

10.1.1 Displaying a Selection List

Select SHOW LIST and press **ENTER** to display the selection list as it would appear in the program branch PARAMETER.

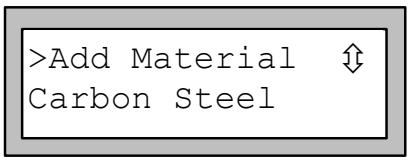
The current selection list is displayed as a scroll list on the second line of the screen. User materials/media are always part of the current user-defined selection list.

Press **ENTER** to leave the current selection list and return to the selection list edition menu.

10.1.2 Adding a Material/Medium to the Current List

To add a material/medium to the current selection list, select ADD MATERIAL or ADD MEDIUM.

Confirm by pressing **ENTER**.



US300PM displays as a scroll list on the second line all materials/media which are not in the current selection list.

Select the material/medium to be added and press **ENTER**.

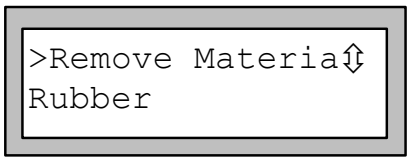
The material/medium is added to the selection list.

Note:	The materials/media will appear in the list in the order in which they have been added.

10.1.3 Deleting a Material/Medium from the Current List

To remove a material or a medium from the selection list, select REMOVE MATERIAL or REMOVE MEDIUM.

Confirm by pressing **ENTER**.



US300PM displays as a scroll list on the second line all materials/media of the current selection list.

Select the material/medium to be removed and press **ENTER**. The material/medium is deleted from the selection list.

Note:	User materials/media are always part of the current user-defined selection list. They cannot be deleted.

10.1.4 Deleting all Materials/Media from the Current List

Select REMOVE ALL and press **ENTER** to remove all materials/media from the current selection list. User materials and media will not be removed.

Note:	User materials/media are always part of the current user-defined selection list. They cannot be deleted.

10.1.5 Adding all Materials/Media to the Current List

Select ADD ALL and press **ENTER** to add all materials/media of the internal data bank to the current selection list.

10.2 Defining New Materials and Media

It is possible to add self-defined materials or media ("user materials" or "user media") to the internal data bank. These entries are stored in the coefficient storage ("user area").

The number of user materials/media that can be defined depends on the partitioning of the user area (see section 10.2.1). The user materials/media will appear in the selection lists of the program branch PARAMETER. The storage of user defined materials and media is cold-start resistant and remains active even if the unit has been switched off.

The basic properties of a medium are its maximal and minimal sound velocities, its viscosity and its density. The basic properties of a material are its transversal and longitudinal sound velocities and its typical roughness.

Note:	The user area must be partitioned before any data can be stored.

10.2.1 Partitioning the User Area

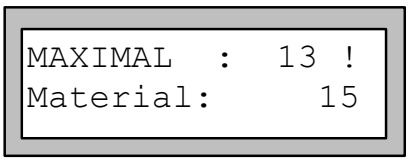
The capacity of the user area can be parted as you like among the following data set types:

- Basic data of a material (sound velocity, typical roughness)
- Basic data of a medium (sound velocity, viscosity, density)

The maximal number of data sets for each of these categories are given in the following table:

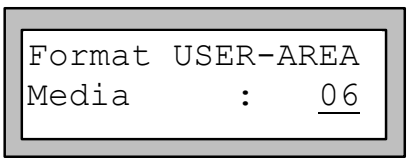
	Maximum number of data sets	Corresponding occupancy of the User Area in %
Materials	13	97
Media	13	95

In the SPECIAL FUNCTIONS \ SYSTEM SETTINGS \ LIBRARIES program branch, select the entry FORMAT USER-AREA. Confirm by pressing **ENTER**.



In the following, a message will be displayed if the selected number of data sets for a certain type of data would overflow the capacity of the user area.

Enter the wanted number of user materials.

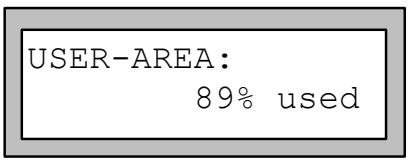


Enter the wanted number of user media.

Enter 0 here. The definition of heat flow coefficients is not possible on this instrument at the moment.

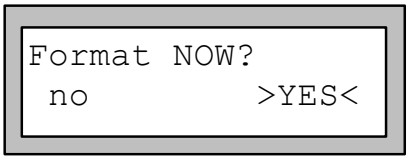
Enter 0 here. The definition of steam coefficients is not possible on this instrument at the moment.

Enter 0 here. The definition of concentration coefficients is not possible on this instrument at the moment.



US300PM displays for a few seconds the occupancy of the user area for the selected partition.

(89 % corresponds to the given example: 6 data sets for material and 6 for media, 0 for heat coefficients, 0 for steam coefficients, 0 for concentration coefficients)



US300PM asks for confirmation of the selected partition. Select YES to proceed to partitioning.

US300PM formats the user area according to your inputs. This procedure takes a few seconds.

Once the formatting is finished, US300PM will return to the FORMAT USER-AREA display.

Keeping Data during Formatting of the User Area

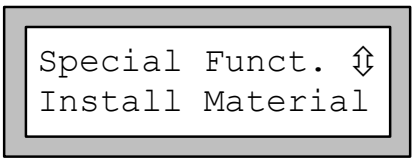
When reformatting the User area, US300PM can keep up to 8 data sets of each type.

Example 1: You reduce the number of user materials from 5 to 3. The data sets #01 to #03 are kept. The last two data sets #04 and #05 are deleted.

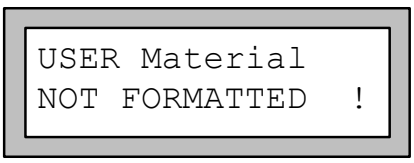
Example 2: You increase the number of user materials from 5 to 6. All 5 data sets are kept.

10.2.2 Input of the Material/Media Properties

The procedures for the input of material and medium properties are the same.

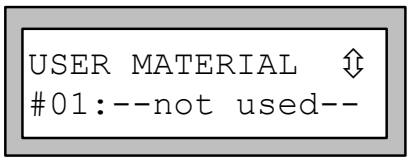


In the program branch SPECIAL FUNCTION select INSTALL MATERIAL or INSTALL MEDIUM and press **ENTER**.

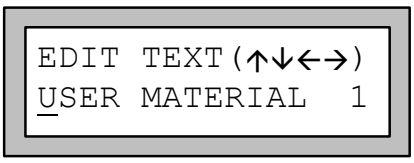


An error message appears in case you did not reserve data sets for user materials or user media when formatting the user area. In this case, partition the user area according to your needs (see section 10.2.1).

Select EDIT and press **ENTER**.

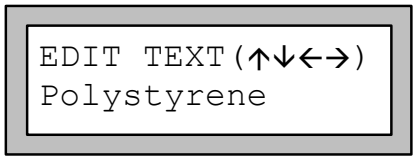


Select one of the available memory locations and confirm by pressing **ENTER**.



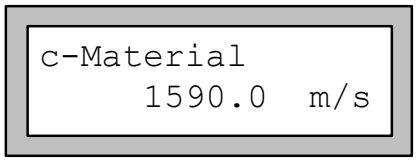
Default name for a user material or medium is "USER MATERIAL N" or "USER MEDIUM N", with N an entire number. This designation can be modified now.

Note:	There are 95 ASCII-characters (letters, capital letters, numbers, special characters [! ? " + - ( ) > < % * ~ etc.] available for the designation of your material/medium, with a maximum of 16 characters per designation. The input of text is described in section 4.2.1, the selection of the input mode in section 11.2.3.



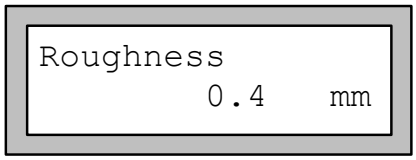
Press **ENTER** when the edition of the designation of the material is finished.

FOR A MATERIAL:



US300PM asks for the sound velocity of the material. Table 1 of Appendix B gives the sound velocities of some materials. Values between 600.0 and 6553.5 m/s are accepted.

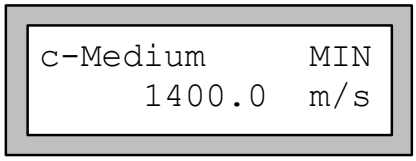
Confirm by pressing **ENTER**.



Enter the roughness of the pipe, taking into consideration the state of the pipe. Table 2 of appendix B gives typical roughness values of pipes.

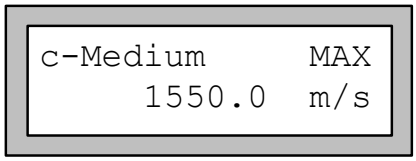
Confirm by pressing **ENTER**.

FOR A MEDIA:



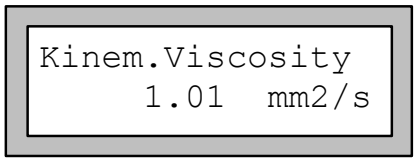
Enter the minimum value of the sound velocity (in m/s) for the medium you want to measure. Values between 800 and 3500 m/s are allowed.

Confirm by pressing **ENTER**.



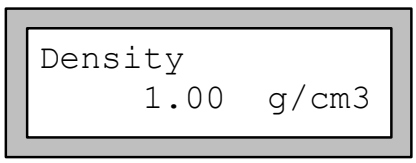
Enter the maximum value of the sound velocity (in m/s) for the medium you want to measure. Values between 800 and 3500 m/s are allowed.

Confirm by pressing **ENTER**.



Enter the kinematic viscosity of the medium. Values between 0.01 and 30,000.00 mm^2/s are accepted.

Confirm by pressing **ENTER**.

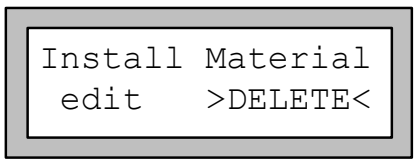


Enter the density of the medium.

Confirm by pressing **ENTER**.

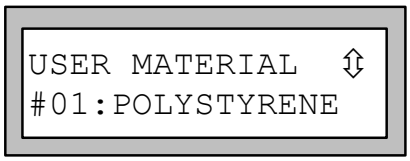
10.2.3 Deleting a User Material or User Medium

To delete a user material or medium, proceed as follows:



In the program branch SPECIAL FUNCTION, select INSTALL MATERIAL or INSTALL MEDIUM and press **ENTER**.

Select DELETE and confirm by pressing **ENTER**.



Select the user material or medium to be deleted and confirm by pressing **ENTER**.

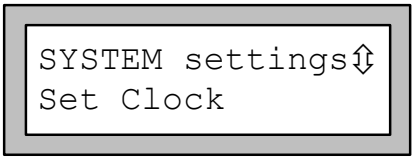
US300PM asks for confirmation. Select YES or NO and press **ENTER**.

11 System Settings

11.1 Setting the Internal Clock

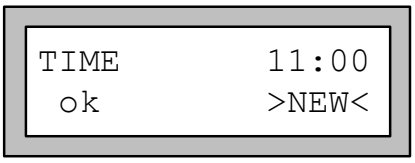
US300PM features a battery buffered clock. During measurement, the data are automatically stamped with date and time.

11.1.1 Setting the Time



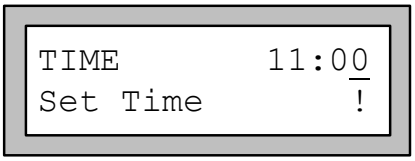
Select SPECIAL FUNCTION \ SYSTEM SETTINGS \ SET CLOCK.

Confirm by pressing **ENTER**.



The actual time is displayed. Select OK to confirm or NEW to set the time.

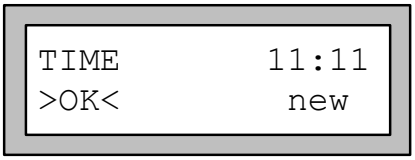
Confirm by pressing **ENTER**.



Use key 4 or 6 to select the digit to be edited.

Use key 8 and 2 to edit the selected digit.

Confirm by pressing **ENTER**.

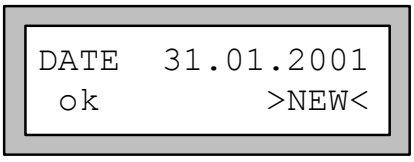


The next display shows the newly set time. Select OK to confirm or NEW to set the time again.

Confirm by pressing **ENTER**.

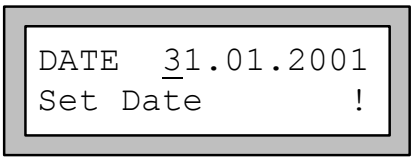
11.1.2 Setting the Date

Note:	The date is displayed in the format DD.MM.YYYY, where DD is the day, MM the month and YYYY the year.



After the time has been set, the DATE display will appear. Select OK to confirm or NEW to set the date.

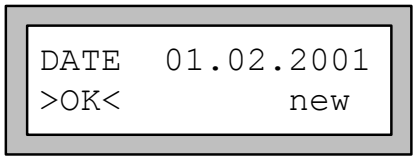
Confirm by pressing **ENTER**.



Use key 4 or 6 to select the digit to be edited.

Use key 8 and 2 to edit the selected digit.

Confirm by pressing **ENTER**.



The next display shows the newly set date and asks for confirmation. Select OK to confirm or NEW to set the date again.

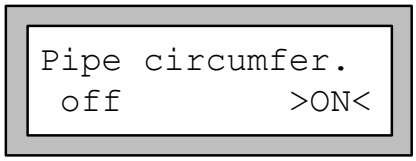
Confirm by pressing **ENTER**.

11.2 Settings for the Dialogues and Menus

In the program branch SPECIAL FUNCTION, select the SYSTEM SETTINGS, then the DIALOGS/MENUS option.

Note:	US300PM stores the DIALOG/MENUS settings at the end of the dialogue. If you leave the program branch before the end of the dialogue, your settings won't be effective.

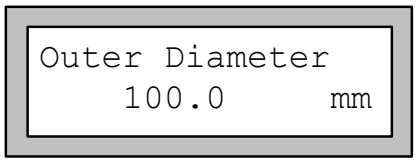
11.2.1 Input of the Pipe Circumference



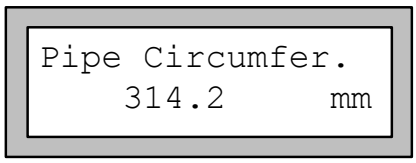
ON enables you to enter the pipe circumference instead of the pipe diameter in the program branch PARAMETER.

This setting is cold-start resistant.

Confirm by pressing **ENTER**.

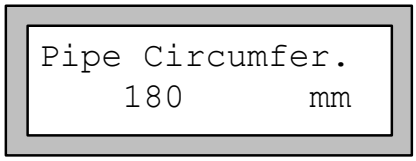


When the PIPE CIRCUMFERENCE option is ON, US300PM will still first ask for the outer diameter in the program branch PARAMETER. However, you can switch to the CIRCUMFERENCE display by entering 0 (zero) and pressing **ENTER**.



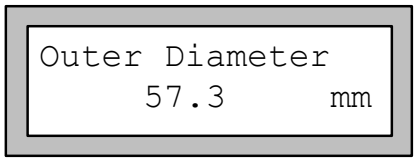
The value displayed in the CIRCUMFERENCE display is calculated using the last displayed value of the outer diameter.

(For example: 100 mm x π = 314.2 mm)



You can now enter the circumference of the pipe.

(The parameter limits for the circumference are calculated using the limits for the outer diameter.)



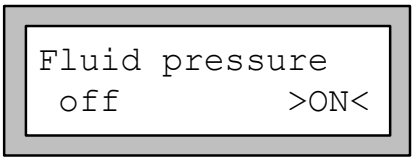
During the next scroll through the program branch PARAMETER, the outer diameter corresponding to the entered circumference will be displayed.

(For example: 180 mm : 3.142 = 57.3 mm)

Note:	The edition of the circumference is of a temporary nature. When the unit switches back to the display of the pipe circumference (internal re-calculation), slight rounding errors may occur. Example: Entered circumference = 100 mm -> displayed outer diameter = 31.8 mm. When the unit switches back to the circumference internally, a value of 99.9 mm will be displayed.

11.2.2 Input of the Fluid Pressure

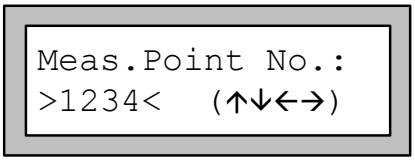
US300PM can take into account the dependency of fluid properties on pressure.



In the FLUID PRESSURE display, select ON if you wish to enter the fluid pressure in the program branch PARAMETER. The value of the fluid pressure must lie between 1 and 600 bar.

If you select OFF, US300PM uses a fluid pressure of 1.0 bar for all pressure dependent calculations.

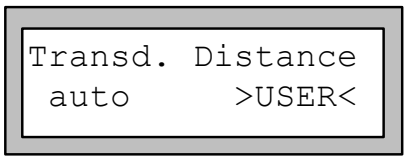
11.2.3 Input mode for the Measuring Point Designation



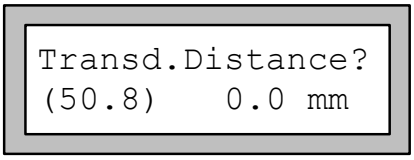
Select "1234" if you wish to identify the measuring points using only numbers, point and dash.

Select "↑↓←→" if you wish to enter the measuring point designations using the ASCII-editor.

11.2.4 Display of the Last Entered Transducer Distance



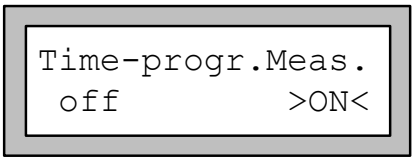
If you select TRANDUCER DISTANCE \ USER, US300PM will display the last precise transducer distance you have entered after positioning of the transducers.



If the suggested transducer distance and the entered distance are not identical, the suggested value is then displayed in parenthesis on the left, followed by the last precise transducer distance entered. **This setting is recommended if you always measure at the same measuring point.**

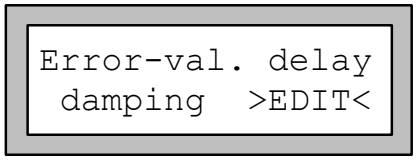
If you select TRANDUCER DISTANCE \ AUTO, US300PM will only display the suggested transducer distance after the positioning of the transducers. **This setting is recommended if the measuring point changes often.**

11.2.5 Time-programmable Measurement



Select ON to enable the time-programmable measuring mode (see chapter 13), OFF to disable it.

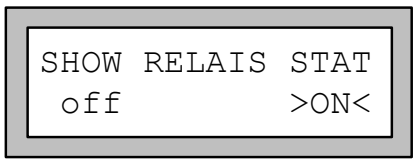
11.2.6 Error-Value Delay



EDIT enables you to enter an error-value delay. The error-value delay is the time after which a special error value will be sent to an output when no valid measured values are available. If you select DAMPING, US300PM uses the value of the damping as error-value delay.

See section 15.1.1 and 15.2 for more information on the behavior of US300PM in case no measured values can be obtained.

11.2.7 Display of the Alarms' State

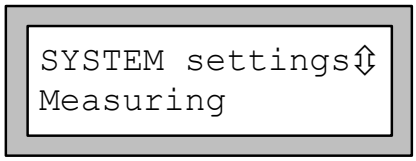


ON activates the display of the alarms' state during measurement.

See section 15.6 for more information on the alarms.

Note:	US300PM stores all changes now at the end of the configuration dialogue.

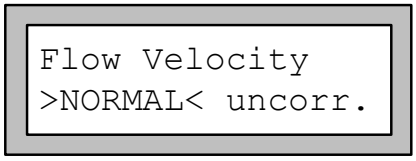
11.3 Measurement Settings



In the program branch SPECIAL FUNCTION, select the SYSTEM SETTINGS, then the MEASURING option.

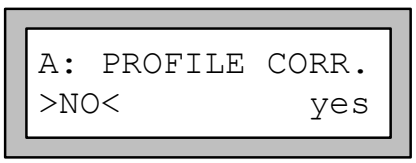
Note:	US300PM stores the MEASURING settings at the end of the dialogue. If you leave the program branch before the end of the dialogue, your settings won't be effective.

Always select OFF here. Confirm by pressing **ENTER**.

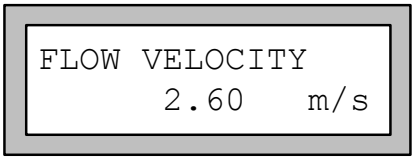


In the FLOW VELOCITY display, select NORMAL to have the profile corrected flow velocity displayed and output. Select UNCORR. to enable the display of flow velocities without flow profile correction. This setting is cold-start resistant.

Confirm by pressing **ENTER**.



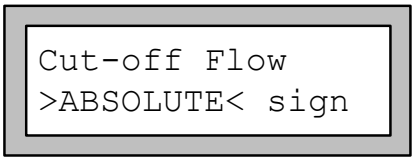
If you have selected UNCORR in the previous display, US300PM will ask the MEASURING program branch explicitly whether to use the profile correction for the selected channel or not.



If you select NO, the profile correction will be completely disabled. All measuring quantities will be calculated with the uncorrected flow velocity. The designations of the measuring quantities will be displayed in capital letters to indicate this.

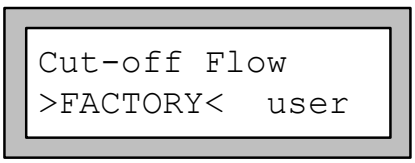
If you select YES, US300PM uses the uncorrected flow velocity only if the physical quantity FLOW VELOCITY is selected in the OUTPUT OPTIONS. US300PM determines all other physical quantities (volume flow, mass flow, etc.) with the corrected flow velocity. During measurement, FLOW VELOCITY will be displayed in capital letters, indicating that the displayed flow velocity is uncorrected.

Confirm your selection by pressing **ENTER**.



If you select ABSOLUTE, the user defined cut-off flow rate will not depend on the sign identifying the direction of flow. There is only one limit to be set. The absolute value of the measured value will be compared with the cut-off flow.

If you select SIGN, the user defined cut-off value will depend on the sign identifying the direction of flow. Two independent limits can be entered for positive and negative flow velocities (see section 7.4).

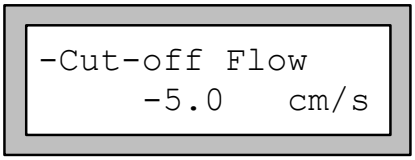


If you select FACTORY, US300PM will use the factory default setting of 5 cm/s for the cut-off flow (see section 7.4).

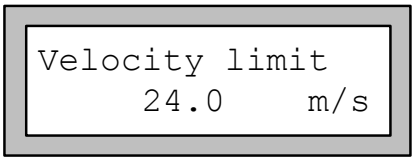
Select USER to define the cut-off flow rate in absolute or sign dependent input format.

Confirm by pressing **ENTER**.

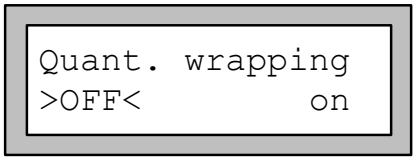
This display appears only if you have selected the USER CUT-OFF FLOW. Enter here the cut-off flow for positive measured values. Should the measured value fall below this threshold, a flow velocity of 0 cm/s will be used for further calculation.



This display appears only if you have selected the USER CUT-OFF FLOW. Enter here the cut-off flow for negative measured values. Should the measured value rise above this threshold, a flow velocity of 0 cm/s will be used for further calculation.



You can enter here an upper limit for the flow velocity (see section 7.3). Values between 0.1 and 25.5 m/s are accepted. Entering 0.0 switches off the test for outliers.



Select here the overflow option for the flow totalizers. Select ON to work with overflow: The totalizer resets automatically to 0.000 as soon as ±9999999999 is reached (as for a water-clock).

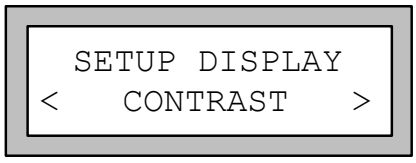
Select OFF to work without overflow: The numerical value of the respective totalizer increases up to the internal limit of 10^{38}. The values are displayed as exponential numbers (±1.00000E10) if necessary.

In the QUANTITY RECALL display, select ON if you wish that the previous numerical values of the totalizers are kept after restart of the measurement. Select OFF if you wish the totalizers to be reset to zero after restart of the measurement.

Note:	US300PM stores all changes of the SYSTEM SETTINGS now at the end of the dialogue.

11.4 Setting the Contrast

In SPECIAL FUNCTION \ SYSTEM SETTINGS, select MISCELLANEOUS and press **ENTER**.



Set the contrast of the display using the following keys:

6 Q+ increases contrast.

Q- **4** decreases contrast.

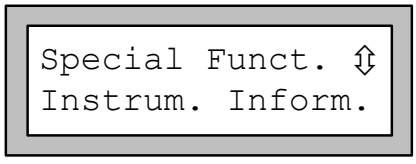
2 Q_{OFF} = minimum contrast

5 = medium contrast

Q_{ON} **8** = maximum contrast

The contrast will be reset to "medium" after a coldstart.

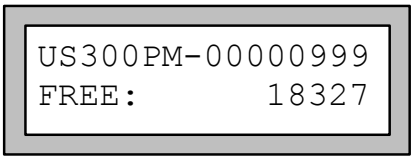
11.5 Instrument Information



Select SPECIAL FUNCTION \ INSTRUM. INFORM. to obtain information about the flowmeter:

- the type designation and the factory number of your instrument,
- the memory still available for data storage,
- the version of the firmware.

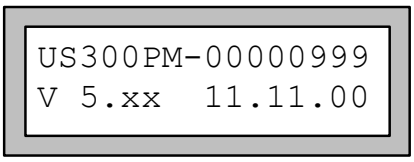
Confirm by pressing **ENTER**.



The type designation and the serial number of your instrument are given on the first line. Here: Type designation = US300PM and factory number = 00000999

The memory still available for data storage is given on the second line. Here: 18327 measured values can still be stored.

Confirm by pressing **ENTER**.



The type designation and the serial number of your instrument are given again on the first line.

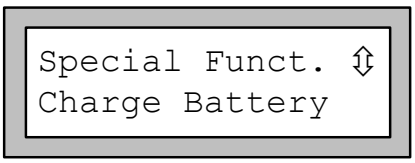
The firmware version and its date are given on the second line. Here: Version V5.xx from 11/11/ 2000

Confirm by pressing **ENTER**.

11.6 Charging the Battery

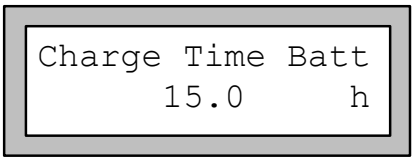
The chargeable NiCd-batteries guarantee an operating time of approximately 14 hours. The flowmeter can also operate from an external power supply of 100 to 240 VAC. The power adapter/battery charging unit can be used for this purpose.

During battery charging, the battery set must remain in the battery compartment of the instrument. Connect the power adapter/battery charging unit to the flowmeter (make sure that the plug snaps in correctly) and to the mains.



In the main menu, select SPECIAL FUNCTION \ CHARGE BATTERY.

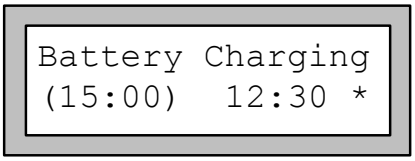
Confirm by pressing **ENTER**.



Enter the desired charging time of the battery (maximum: 15 h).

Confirm by pressing **ENTER**.

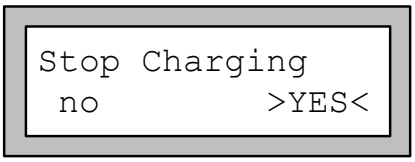
The charging time of the battery is 15h. The charging current is 400 mA.



The selected charging time is displayed in parenthesis on the left of the display. The remaining charging time is displayed on the right.

A "*" is displayed every second to signal that the charging process is running.

During battery charging, the battery status LED is red. When you press **ENTER**, the charging process continues in background mode, and the following display appears:

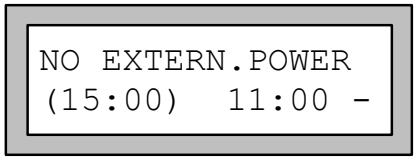


Select YES and confirm by pressing **ENTER** to stop the battery charging process. The main menu will appear.

Select NO and **ENTER** to continue the battery charging process in the background. The main menu will appear.

This message will appear when the battery charging process is completed, provided it did not run in background mode.

Should the external power supply be disconnected, the following error message will appear:



US300PM stops the battery charging process. The remaining charging time will be saved (for example 11:00). When the external power supply is reconnected, the charging will continue for the remaining time.

If there is a battery charging error, i.e. there is no external power supply, the battery status display flashes (0.5 Hz).

Attention!

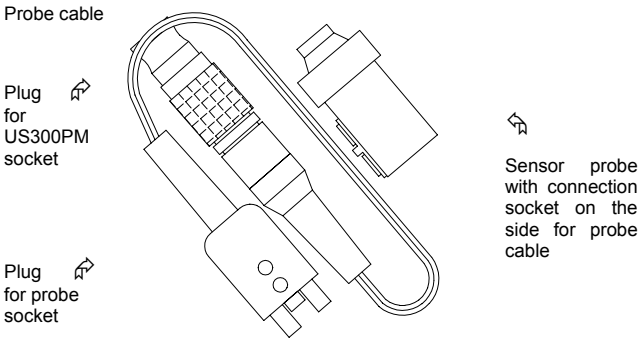
- Use only the battery set authorized by Yokogawa. This battery set can be ordered from your local Yokogawa sales office.

  The use of non-rechargeable batteries is prohibited.
- Take care to plug correctly the connector: its shape prevents from reversing the polarity.

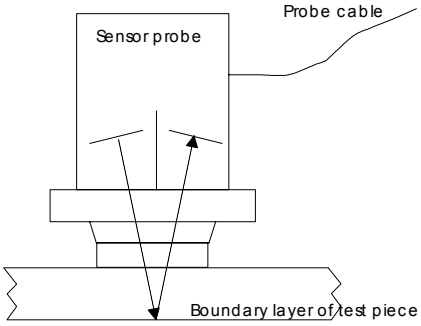
12 Wall Thickness Measurement

Equipped with the Wall Thickness Measurement (WTM) option, US300PM can be used to measure wall thickness and the **longitudinal** sound velocity in a material. A dedicated wall thickness sensor to be connected directly with the sensor connection socket is supplied. US300PM will automatically recognize the wall thickness sensor when connected. The wall thickness measuring values can easily be transferred into the current parameter record for the flow measurement.

US300PM with WTM option uses a modified transit-time method to determine the thickness or sound velocity of a material (test piece). The sensor probe emits a short ultrasonic pulse which propagates in the test piece. The pulse is reflected by the boundary layer of the test piece and comes back to the sensor probe. The time difference between the emission and the reception of the signal is a measure for the thickness of the test piece (with known sound velocity of the material) or for its longitudinal sound velocity (with known thickness of the material).


Probe cable
Plug for US300PM socket
Plug for probe socket
Sensor probe with connection socket on the side for probe cable

Wall thickness sensor assembly



Measuring principle

Note:	With some exceptions, the transversal sound velocity for a material is about 30% to 60% of the longitudinal sound velocity.

12.1 Activating the WTM Mode

To activate the WTM mode, insert the plug of the probe cable into the socket for channel A or B at the front of the unit. US300PM automatically switches to the WTM mode

This message appears for 1 second. It acknowledges the detection of the probe on channel A and shows that the WTM option is available.

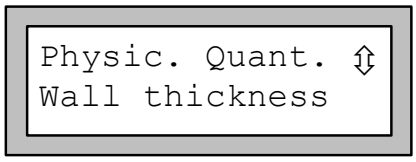
The main menu of the WTM option is displayed. The menus are similar to those of the flow measurement mode. The program branches are adapted to wall thickness measurement.

Note:	• As long as the probe is connected to the socket of a measuring channel, US300PM stays in wall thickness measurement mode on that channel. • The parameter record for the flow measurement will not be influenced, with the exception of the possible change of the measured pipe wall thickness.

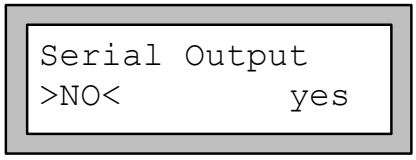
12.2 Parameter Input

12.2.1 Parameter Input for Wall Thickness Measurement

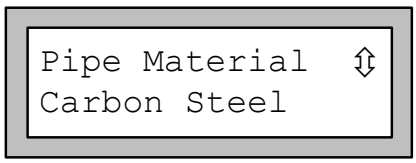
In order to determine the wall thickness, the sound velocity of the material must be entered.



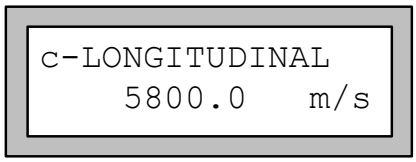
In the program branch OUTPUT OPTIONS, select the physical quantity WALL THICKNESS for the channel on which the probe is connected. Confirm by pressing **ENTER**.



US300PM asks for using the SERIAL OUTPUT option. Select YES or NO and confirm by pressing **ENTER**. The main menu will appear.



Select in the PIPE MATERIAL selection list of the program branch PARAMETER the material the pipe you want to measure is made of. If the material is not part of the list, select OTHER MATERIAL. Confirm by pressing **ENTER**.



The longitudinal sound velocity in the selected material is displayed as a suggestion. If you have selected OTHER MATERIAL in the previous display, 0.0 m/s is displayed. Edit the velocity if necessary. The maximal sound velocity that can be entered is 20.000 m/s.

Confirm by pressing **ENTER**.

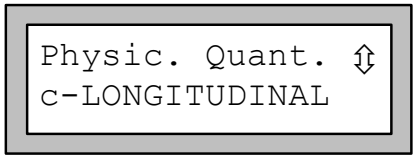
Note:

- The measurement will only start if a c-LONGITUDINAL other than zero is entered.
- Unlike in the case of flow measurement, the sound velocity has here a great influence on the result. It influences the measuring result in an approximately linear fashion. Thus, the input of a sound velocity 10% higher than the actual one gives a wall thickness approximately 10% too high.
- The actual sound velocity of a material often differs substantially from the values published in the literature because it depends on the composition and on the manufacturing process of the material as well as on temperature. The sound velocities given in Table 1 of Appendix B should only serve as orientation values.
- The longitudinal sound velocity can be measured precisely using a comparative block of known thickness. See section 12.3.1.

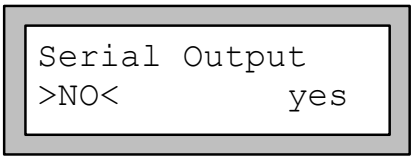
When you go through program branch PARAMETER for the first time after switching to WTM mode, the pipe material selected for clamp-on flow measurement will appear in the selection list.

12.2.2 Parameter Input for Measuring the Sound Velocity

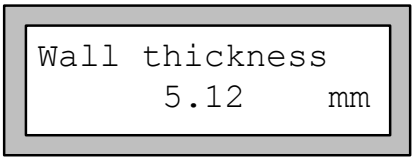
In order to determine the longitudinal sound velocity in a material, the thickness of the test piece must be entered.



In the program branch OUTPUT OPTIONS, select the physical quantity c-LONGITUDINAL for the channel on which the probe is connected. Confirm by pressing **ENTER**.



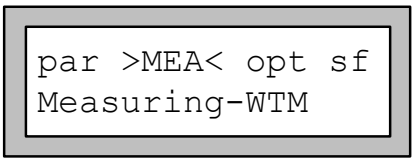
US300PM asks for using the SERIAL OUTPUT option. Select YES or NO and confirm by pressing **ENTER**. The main menu will appear.



In the program branch PARAMETER for the channel on which the probe is connected, enter the wall thickness of the test piece. Values between 0.8 mm and 200 mm are allowed.

Note:	The wall thickness influences the measuring result in an approximately linear fashion. Thus, the input of a wall thickness 10% higher than the actual one gives a sound velocity approximately 10% too high.

12.3 Measurement



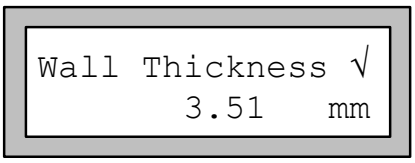
Select in the main menu the program branch MEASURING. Confirm by pressing **ENTER**.

If this error message appears:

- you did not enter all the required parameters or
- the sound velocity for the material was set to 0.0 m/s.

12.3.1 Measurement of Wall Thickness

This display appears if the wall thickness was selected as quantity of measurement for the channel on which the probe is connected. As long as there is no valid measured value, the unit of measurement and a question mark are shown on the lower display line.



Apply a film of acoustic coupling compound on the test piece (the pipe). Firmly press the probe against the test piece. As soon as a valid measured value is obtained, the measured thickness is displayed on the second line. A tick is displayed on the right of the first line. The measured value remains on the display when the probe is taken off the material.

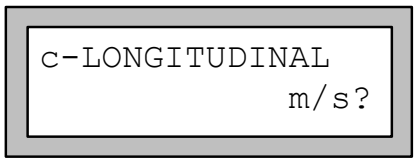
To minimize errors during the measurement of the wall thickness:

Measure the actual longitudinal sound velocity of the material using a comparative block of the same material with known dimensions.

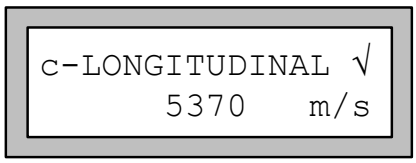
- The comparative block should be even and plain.
- The thickness of the comparative block should be comparable to the maximum thickness of the test piece (the pipe).

Attention!	The sound velocity of the material depends on the temperature. The measurement of the sound velocity using a comparative block should thus be performed at the location where flow measurement will be performed later, in order to minimize the effect of temperature fluctuations.

12.3.2 Measurement of Sound Velocity



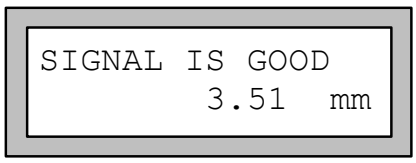
This display appears if the sound velocity was selected as quantity of measurement for the channel on which the probe is connected. When there is no valid measured value, the unit of measurement and a question mark are shown on the lower display line.



Apply a film of acoustic coupling compound on the test piece (the pipe). Firmly press the probe against the test piece. As soon as a valid measured value is obtained, the measured thickness is displayed on the second line. A tick is displayed on the right of the first line. The measured value remains on the display when the probe is taken off the material.

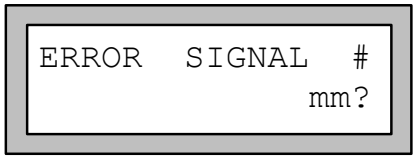
12.3.3 Further Information about the Measurement

Use keys 3 DISP and DISP 9 to switch ON or OFF the display of information about the measurement status .



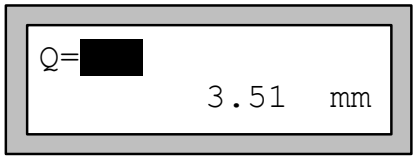
Press key DISP 9 to obtain information about the signal.

If the signal is sufficient for measurement, the message "SIGNAL IS GOOD" appears. The SIGNAL LED shows green.



If the signal is sufficient for measurement, the message "ERROR SIGNAL #" (with # a number) appears. The SIGNAL LED shows red.

("#" is a number.)

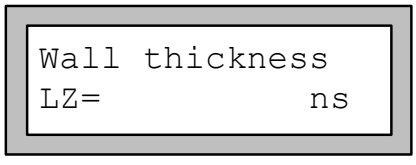


Press key DISP 9 again.

The bar graph indicating the quality of the signal ("Q=") will appear.

If the signal quality is insufficient for measurement, "UNDEF" appears on the bar graph. The SIGNAL LED shows red.

In this case, adjust the transducers by moving them slightly until the SIGNAL LED shows green.



Press key 3 DISP to have the transit time ("LZ") in nanoseconds displayed.

12.3.4 Failure of Measurement

If no valid thickness can be obtained:

- Take the probe off the test piece (the pipe).
- Clean the probe and the area of the test piece where the measurement takes place.
- Apply a film of acoustic coupling compound onto the test piece and/or the probe.
- Firmly press the probe against the test piece.
- Try measuring again.

Note:	• Use a small amount of coupling compound. Always apply the coupling compound in the same way to avoid errors caused by different film thickness. • Apply constant pressure when pressing the probe against the test piece.

12.3.5 Reasons for Incorrect Measuring

Temperature fluctuations

The sound velocity of the material is temperature dependent.

Doubling effect

When measuring wall thickness using ultrasonic signals, a phenomena called 'doubling effect' can be observed in situations where the thickness of the material is smaller as the lowest measuring range of the probe. The measured value is then twice (or sometimes three times) as big as the actual thickness of the material because of unwanted reflections of the sound signal.

Measured value is too small

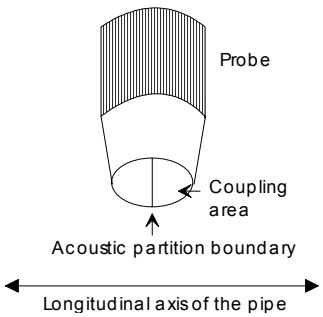
A value considerably smaller than expected might be caused by a material defect. The ultrasonic signal was reflected by the material defect in the material and not by the boundary layer, leading to a shorter transit time and thus a smaller thickness.

Surface condition

Periodical unevenness (e.g. small grooves) on the surface of a measuring object can lead to wrong measuring results. Normally, this problem can be overcome by turning the probe so that the acoustic partition boundary of the probe (see drawing below) is perpendicular to the orientation of the grooves.

In some cases, measuring on a rough surface with too much coupling compound will lead to wrong measured values. Measurement on very rough surfaces might be impossible (the display will show "`No Coupling`"). In such a case, the surface should be treated and smoothed out accordingly.

Curved surfaces



During measurements on pipes or cylindrical containers, the probe must be pressed as centrally as possible against the object. Applied pressure must be constant.

The acoustic partition boundary of the probe must be perpendicular to the longitudinal axis of the object being tested.

12.3.6 Storage / Transfer of Thickness Value

Press **ENTER** to end measurement run and store or output the measured value.

The following display appears when a valid measurement of the wall thickness has been obtained and one of the available output options is activated:

Select `YES` to store and/or output the obtained measured value.

- If you have measured the wall thickness, this value will be transferred into the current parameter record for the clamp-on flow measurement. The pipe material of the parameter record will be replaced by the material used for the thickness measurement.
- If the serial output is activated, the measured value will be transmitted.

12.3.7 Leaving the WTM Mode

You can leave the wall thickness measurement mode as follows:

- Disconnect the sensor probe from the US300PM socket while in program branch `MEASURING`.

Otherwise:

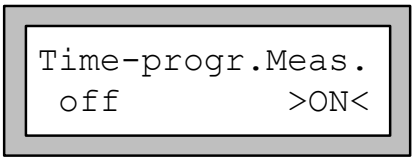
- Return to the main menu of the WTM option by pressing **BRK**.
- Disconnect the plug from the US300PM socket.

13 Time-programmable Measurement

The time-programmable measuring mode allows the user to program the beginning and the end of a measurement. In stand-by and with reduced power consumption, US300PM will wait for the defined start time and then start the measurement automatically (storage and output of measured values). US300PM can also automatically stop the measurement. The power consumption during standby is greatly reduced, thus contributing to extend the operational time of the unit while working in battery mode. The time-programmable measurement allows you to record process data at a high storage rate at the needed time, instead of having to measure the whole time at a low storage rate in order to have enough storage capacity left when needed.

13.1 Enabling and Disabling

The time-programmable measuring mode can be enabled and disabled in the program branch `SPECIAL FUNCTION \ SYSTEM SETTINGS \ DIALOGS/MENUS` and is cold-start resistant.



Select the `TIME-PROGR.MEAS.` option.

Select `ON` to enable the time-programmable measuring mode, `OFF` to disable it.

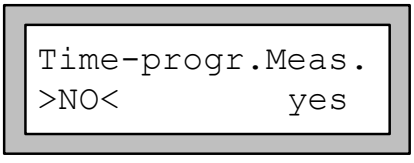
Confirm by pressing **ENTER**.

13.2 Input of the Start Time

Note:	The operations for the time-programmable measuring mode are only possible if in the program branch `OUTPUT OPTIONS` • the storage of measured values or • one of the available outputs (serial, current, binary) was activated.

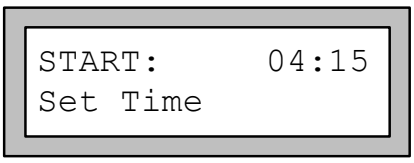
Note:	Every hour US300PM waits for the start time reduces the battery capacity by 2%. This reduces the operating time left for the measurement accordingly.

Once time-programmable measurement is enabled, following display will appear in the program branch `MEASURING`:



Select `YES` to program the time for the measurement.

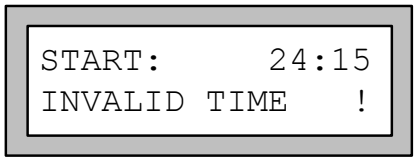
Confirm by pressing **ENTER**.



Select the digits you want to edit using the horizontal cursor keys 4 and 6.

Set the hours or minutes using the vertical cursor keys 2 and 8.

Confirm the entered start time by pressing **ENTER**.

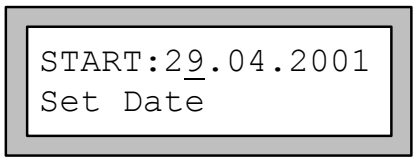


If this error message appears, you have probably made the day longer than it is. The start time must be set between 00:00 and 23:59.

Press any key (except **BRK**) to return to the SET TIME display.

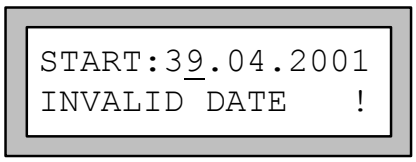
Attention:	The clock function of US300PM works with a 24 hour clock. Times must therefore be specified using the 24-hour style, e.g. 02:35 PM = 14:35.

As soon as a valid start time has been entered, the display to set the start date appears:



Set the day, month and year. Confirm the set start date by pressing **ENTER**.

If the entered start time exists and is in the future, US300PM will ask for the stop time (section 13.3).



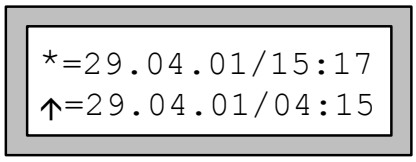
If this error message appears, the date entered does not exist (US300PM also knows leap years!).

Press any key (except **BRK**) to return to the SET DATE display.

If this error message appears, the set start time is in the past.

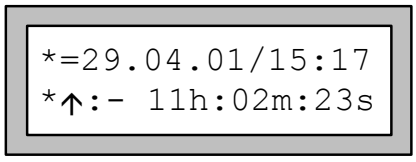
Press any key (except **BRK**) to confirm this message.

Attention:	The seconds for the start time are set to zero automatically. Therefore, the set start time must be at least one minute ahead of the actual time.



US300PM then displays the actual US300PM time on the upper display line ("*=") and the programmed start on the lower line ("↑=).

Here, it can be seen that the programmed start is invalid because it is in the past ("↑=).

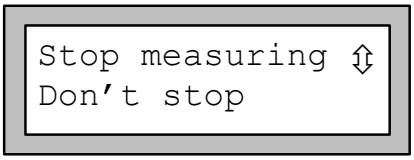


Use keys DISP **9** and **3** DISP to switch between the display of the start time and the display of the difference between the start time and the actual time ("*↑: -") on the lower display line.

Press any key (except **BRK**) to return to the SET TIME display.

13.3 Input of the Stop Time

US300PM can automatically stop a time-programmed measurement. Shortly after such a stop, the unit switches itself off if it is in battery mode. The STOP MEASURING screen is displayed after the input of the start time.

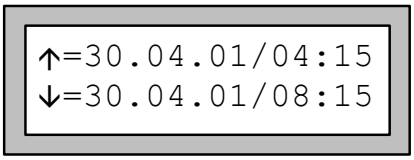


Select one of the options described below and confirm by pressing **ENTER**.

Option	Result
DON'T STOP	Measurement will not be stopped automatically unless if: • the batteries are empty or • the internal memory is full and no output option other than storing has been selected.
STOP: DATE/TIME	You can define the date and time of the automatic stop.
STOP: DURATION	You can define the duration of the measurement. US300PM will then calculate when the measurement should be stopped (START + DURATION = STOP).

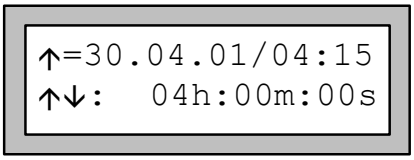
13.3.1 Entering the Stop Time

If you have selected the option STOP: DATE AND TIME in the previous step, enter the date and time for the automatic stop of the measurement in the same way as the start time. Confirm each value with **ENTER**. US300PM will check if date and time entered are valid and will not accept a stop time that is before the previously entered start time.



As soon as you have entered a valid stop, US300PM displays again the start ("↑=") and the stop time ("↓=").

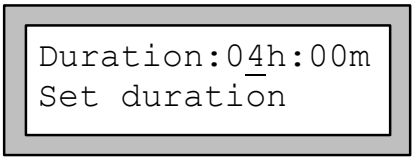
In our example, US300PM starts the measurement on 30/04/2001 at 04:15, will measure for 4 hours and automatically stop the measurement at 08:15.



Using key DISP 9 or 3 DISP, it is possible to switch between the display of the stop time and the display of the duration of measurement ("↑↓:") on the lower display line.

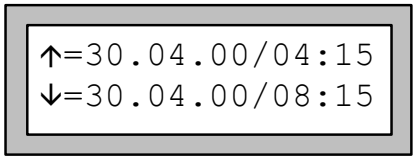
Press any key (except **BRK**) to go to the next option of the MEASURING program branch.

13.3.2 Entering the Duration

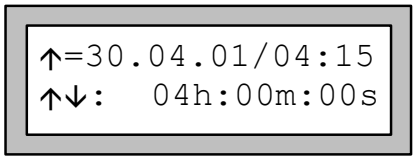


If you have selected the option STOP: DURATION in the previous step, enter the duration of the measurement in the same way as the start time. The maximum measurement duration is of 999 hours and 59 minutes or about 41 days.

Confirm by pressing **ENTER**.



US300PM displays the start time ("↑=") and the stop time ("↓=") calculated using the entered duration.



Use keys DISP 9 and 3 DISP to switch between the display of the stop time and the display of the duration of measurement ("↑↓:") on the lower display line.

Press any key (except **BRK**) to go to the next option of the MEASURING program branch.

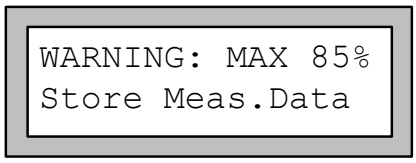
13.4 Measuring with the Time-programmable Mode

When the time-programmable measuring mode is activated, the output options are defined and the start and stop time are set:

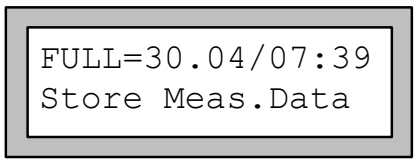
- Start measurement in the usual way. The instantaneous measuring values are displayed and stored and/or transmitted depending on the selected output options.
- Activate all settings needed for the programmed measurement (totalizers, etc.)
- **Press ENTER to start the countdown.** The current measurement will be interrupted and the countdown started.

Note:	The countdown can be stopped at any time by pressing key **BRK**.

The memory requirements for the operational activities to come can now be calculated. If a stop time or a measurement duration has been defined and the storage of measured values is activated, US300PM checks if the free memory capacity is sufficient to store the measured values for the duration of measurement. If it is not, the following display will appear:



In our example, the free memory capacity only covers 85 % of the expected measured values.



Press key DISP 9 and 3 DISP to have the time at which the memory is expected to be full displayed on the upper line of the display.

If storing is the only output option activated, the measurement will be stopped when the memory is full, even if the stop time is not reached. If another output option is also activated, US300PM will continue the measurement until the defined stop time is reached even if the memory is full.

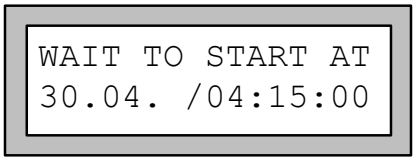
If the free memory capacity is insufficient, try the following:

- Delete all previously stored measured values (SPECIAL FUNCTION \ DELETE MEAS. VAL.).
- Extend the storage interval (OUTPUT OPTIONS \ STORAGE RATE). Doubling the storage interval, e.g. from 'every second' to 'every two seconds' will halve the memory requirement.
- Deactivate the totalizers if possible. The storage of one totalizer value app. triples the memory requirement.
- Check the totalizer storage mode. In SYSTEM SETTING \ STORING \ QUANTITY STORAGE, select ONE if your measurement problem allows the storage of the totalizer for only one flow direction.

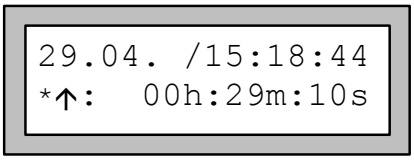
US300PM can be fitted with a memory expansion. Contact your distributor for details.

13.4.1 The Countdown Runs

Note:	The countdown can be stopped at any time by pressing key **BRK**.



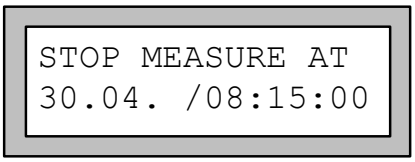
US300PM indicates that the countdown is running. The upper line of the display shows the current status (waiting for the start time) or the current time alternately. The lower line shows the start time.



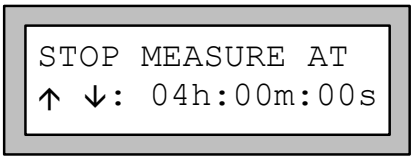
Use key **3** DISP to switch between the display of the start time and the display of the time remaining before measurement start ("*↑") on the lower line.

At any time during the countdown, you can check if a stop time has been programmed. Press key **9** DISP to display information on the upper line.

This message appears on the upper line when no stop time has been programmed.



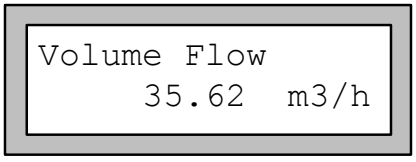
This message shows that US300PM will automatically end the measurement at the displayed time.



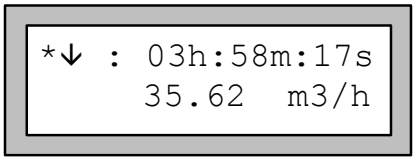
Press key **3** DISP now to display the stop date and time or the programmed duration of the measurement ("↑↓:").

13.4.2 Start/Stop of Measurement

When the defined start time is reached, US300PM continues the previously interrupted measurement. During the measurement, you can check if a stop time has been programmed:



In the volume flow display, press key **9** DISP once or several times.

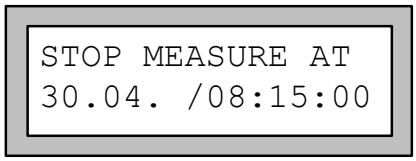


Additional information will be displayed in the upper line giving amongst others the time remaining until automatic stop ("*↓:").

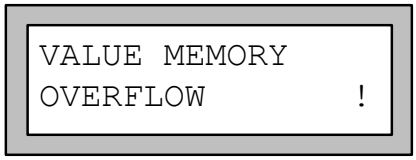
If this message is missing, no stop time has been programmed.

Note:	The programmed measurement can be stopped at any time by pressing key **BRK**.

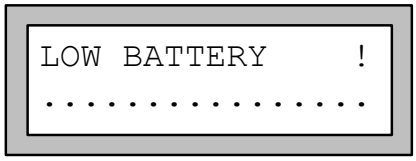
US300PM will automatically stop the programmed measurement in the following cases:



- the programmed stop time has been reached (shortly after this message is shown, US300PM switches off automatically if in battery mode),



- the memory is full and no other output option was activated;



- the battery is empty (shortly after this message is shown, US300PM switches off automatically if in battery mode).

13.5 Storage of Measured Values

- When the storage function is activated, the measured values will be stored in memory after measurement is started. These stored values will be kept when the measurement is interrupted (key **BRK**) to start the countdown or during countdown.
- However, when the programmed measurement is started at the programmed start time, all values stored before the countdown will be disregarded. The first measured value recorded after the automatic start is the first value of the current measuring data set. The start time will be stored as date and time reference for the current measuring data set.

13.6 Online Output

- When the online output via the serial interface is activated, the usual header will be transmitted or printed at the start of the measurement.
- As long as the countdown has not started, the current measured values and totalizer values will be output.
- As soon as the countdown is started, US300PM will confirm that it is waiting for the start time and interrupts measurement.
- When the start time is reached, US300PM will transmit or print date, time and measuring point number.
- Then, after the character string `\DATA`, the measured values will be printed in the normal fashion.
- If the unit works in battery mode and the battery discharged itself during countdown so that the measurement could not be started, this will be acknowledged as follows:

```
\LOWBAT 29.04. /01:30:46
```

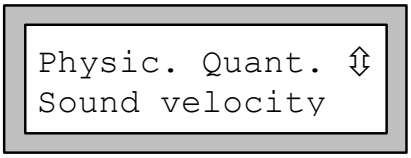
- If the battery goes flat during measurement, this is indicated as follows:

```
\LOWBAT 30.04. /06:13:52
```

- An automatic stop of the measurement by reaching the pre-programmed stop time is indicated as follows:

```
\STOP MEASURE AT : 30.04. /08:15:00
```

14 Measuring the Sound Velocity of the Medium

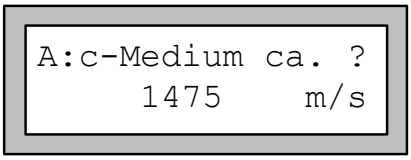


In the program branch OUTPUT OPTIONS, select the channel you want to use to measure the sound velocity. Confirm by pressing **ENTER**. Select the sound velocity as physical quantity of measurement. Confirm by pressing **ENTER**.

Since the sound velocity measurement does not serve for process outputs, online/offline output and storage of measured values, this selection immediately ends the program branch OUTPUT OPTIONS.

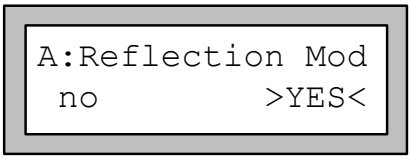
The parameter record (outer diameter, wall thickness) of the selected channel is used for measuring the sound velocity.

To start the measurement of the sound velocity, select the program branch MEASURING and then the channel for which SOUND VELOCITY was set as physical quantity of measurement.

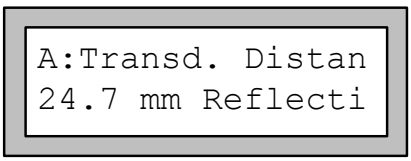


Enter an estimated value for the sound velocity of the medium. Values between 800 and 3500 m/s are accepted.

Confirm by pressing **ENTER**.

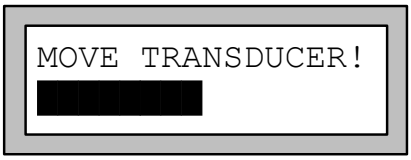


Select YES to measure in reflection mode, NO to measure in diagonal mode. Generally, the correct positioning of the transducers in reflection mode is easier than in diagonal mode.



Mount the transducers on the pipe, taking into account the suggested transducer distance (see section 5.7.1). Confirm by pressing **ENTER**.

(US300PM calculates this first transducer distance on the base of the estimated value of the sound velocity and the actual parameters.)



The amplitude of the received signal is displayed as a bar graph. Move the transducers in direction of another until the bar graph starts to get smaller. One should try to obtain the maximal signal amplitude at the shortest transducer distance possible.

Press keys DISP **9** and **3** DISP to obtain further information on the display (see section 6.3).

Press **ENTER** to conclude the positioning of the transducers.

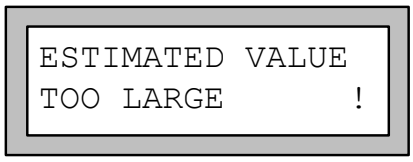
Attention!	Do not move the transducers any more!

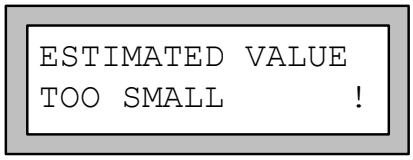
Measure and enter the current (precise) transducer distance.

(In this example, 25.5 mm is the current precise transducer distance.)

Confirm by pressing **ENTER**.

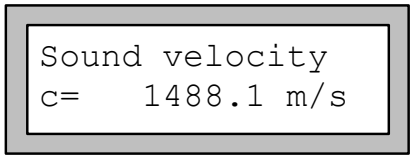
Following error messages might appear at this point:





In both cases, the entered estimated value for the sound velocity differs too much from the real sound velocity of the medium. The transducers were positioned to a disturbance or to an echo.

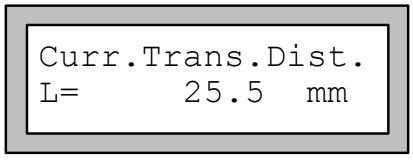
Confirm error messages by pressing **ENTER**. Enter a new estimate for the sound velocity.



As soon as you have entered an estimated value compatible with the real sound velocity of the medium, the measurement starts.

14.1 Displayed Information

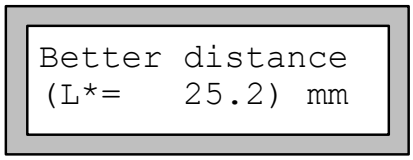
Press keys DISP **9** and **3** DISP to obtain further information in the upper or lower line of the display (see section 6.3).



3 DISP

Current transducer distance (L):

Distance entered during the last positioning of the transducers. The sound velocity is calculated using this value.

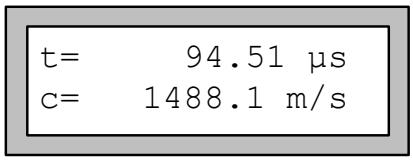


3 DISP

Better distance (L*):

Transducer distance derived from the measured sound velocity.

This allows you to detect wrong positioning. Still, do not change the transducer distance at this point!



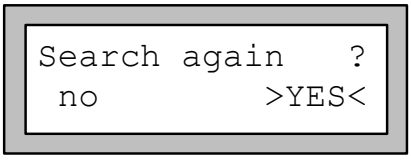
DISP **9**

Signal transit time (t):

The signal transit time in the medium can be displayed on the upper line.

Conclude the ongoing measurement by pressing **ENTER**.

The positioning of the transducers can be repeated now.



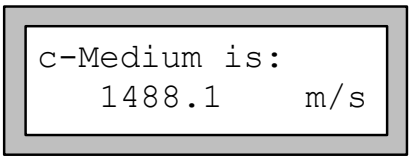
US300PM asks you if you want to search again for the correct transducer distance.

Select NO if the sound velocity of the medium has been measured precisely (wrong positioning of the transducers (|L*-L|) less than 1 mm).

Select YES if the wrong positioning was too large or if no signal was found. A new measurement cycle will be started.

You may repeat the cycle as often as you like. In most cases, however, one or two cycles are quite enough for measuring the sound velocity.

Select YES to store the measured sound velocity as the sound velocity of the medium in the parameter record.



The measured sound velocity can be edited before it is stored in the parameter record.

Confirm by pressing **ENTER**.

The name of the medium in the parameter record is changed to 'Other Medium'.

15 Process Outputs

Your US300PM is equipped with different process outputs (current output, frequency output, binary output). These outputs must be installed and activated before they can be used.

The installation of an output consists of three steps:

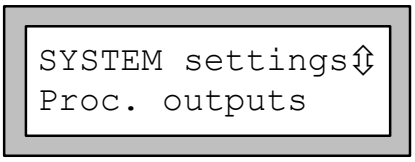
- Assigning a measuring channel (source channel) to the output.
- Defining the measured value the assigned channel should transmit to this output (source item) and the properties of the signal.
- Defining the behavior of the output in case no valid measured values are available.

Only after this procedure has been gone through will measured values be available at the outputs.

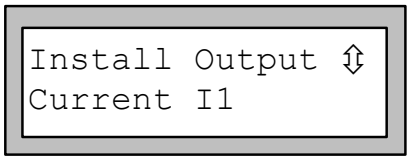
15.1 Installation of a Process Output

The installation of the system outputs takes place in the SPECIAL FUNCTION \ SYSTEM SETTINGS \ PROCESS OUTPUTS program branch.

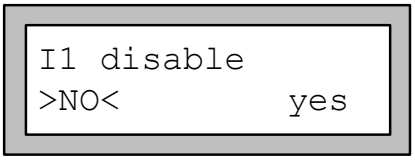
Attention:	US300PM stores the configuration of an output at the end of the installation dialogue. If you leave the installation dialogue by pressing **BRK**, changes won't be saved.



In the SPECIAL FUNCTION \ SYSTEM SETTINGS program branch, select the PROCESS OUTPUTS option. Confirm by pressing **ENTER**.



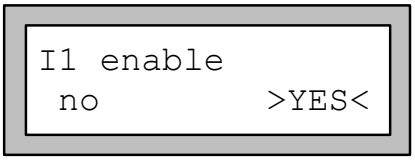
Select the output you want to install. The scroll list contains all the actually available process outputs. A tick (✓) after an item of the list means that this output has already been installed.
Confirm by pressing **ENTER**.



This display appears in case the mentioned output is already installed.

Select NO to edit the configuration of the output.

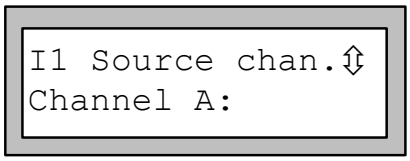
Select YES to disable the output. US300PM then returns to the SYSTEM SETTINGS \ PROCESS OUTPUTS display.



This display appears in case the mentioned output has not been installed yet.

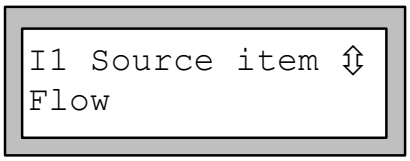
Select YES to install the output and proceed to configuration.

Select NO to return to the SYSTEM SETTINGS \ PROCESS OUTPUTS display.



Select in the scroll list the channel which you want to assign as source channel to the previously selected output.

Confirm by pressing **ENTER**.

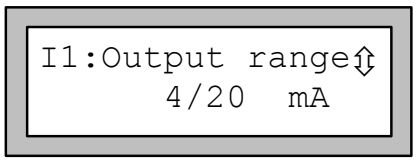


Select the measuring quantity the source channel should transmit to the output (source item). The available source items and their configuration option are described in the table below. If you are configurating a binary output, only the options LIMIT and IMPULSE are offered.

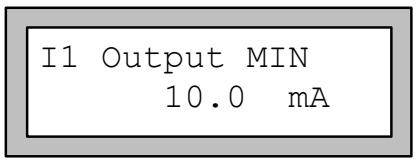
Configuration options for the process outputs

Source item	Available configuration options	Output
Flow	-	Output of the measuring quantity selected in program branch OUTPUT OPTIONS
Quantity	Q+	Output of the totalizer for the **positive** flow direction
	Q-	Output of the totalizer for the **negative** flow direction
	ΣQ	Output of the **sum** of the totalizers
Limit	R1	Output of a limit message (alarm output R1)
	R2	Output of a limit message (alarm output R2)
	R3	Output of a limit message (alarm output R3)
Impulse	From abs (x)	Impulse output without sign consideration
	from x > 0	Impulse output for positive measured values
	from x < 0	Impulse output for negative measured values
Miscellaneous	Soundspeed fluid	Output of the sound velocity of the fluid (see chapter 14).
	Signal	Output of the amplitude of the signal of a measuring channel

15.1.1 Output Range

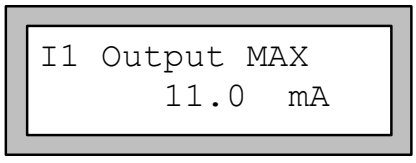


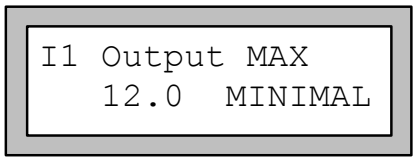
If you are configurating an analogue output, US300PM now asks you for the output range. Select one of the ranges offered in the scroll list or OTHER RANGE to enter manually the output range.



If you have selectes OTHER RANGE, enter the minimal output value (OUTPUT MIN) and the maximal output value (OUTPUT MAX).

Confirm each value by pressing **ENTER**.





The entered output range should cover at least 10% of the full physical output range (I_{MAX} - I_{MIN} ≥ 2mA for a 20 mA current output for example). If this is not the case, US300PM will display the smallest maximal output value (OUTPUT MAX) possible for the entered minimal output value (OUTPUT MIN).

15.1.2 Output Value in Case of Error

In the further dialogue, you can select that value which US300PM shall output in case the assigned source item cannot be measured or located. For example, US300PM might not be capable to measure the flow during a certain period of time because of the presence of gas bubbles in the medium. It will then output the defined "error value".

Following decisions have to be made:

- Which value (‘error value’) shall be recorded and transmitted to the output during this time interval?
- Should this error value be transmitted as soon as no measured values are available, or should the last measured value be transmitted during a certain delay before the error value is transmitted?

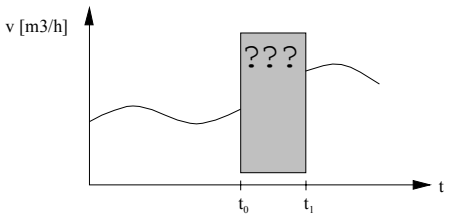
Error-value option	Result
`Minimum`	Output of the lowest possible value (lower limit of the output range)
`Hold last value`	Output of the last measured value
`Maximum`	Output of the highest possible value (upper limit of the output range)
`Other value`	Output of a value to be defined within the physical limits of the output.

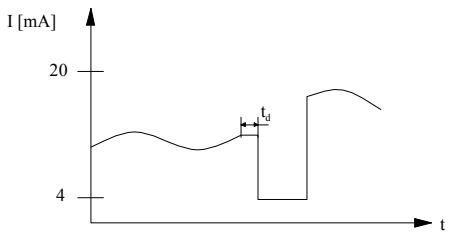
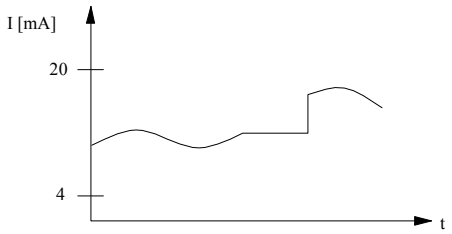
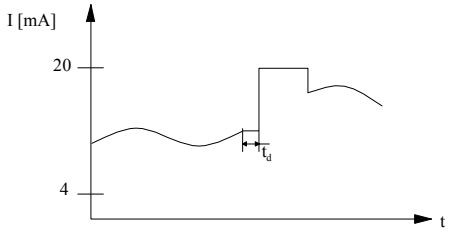
Example:

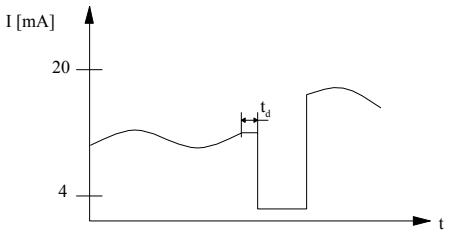
The flow volume was selected as source item for the current output, the current output's range was set to 4/20 mA, the error-value delay t_d to a value greater as zero.

Measurement of the flow volume is impossible during the time interval t_0 to t_1.

What signal should be output during this time interval?



Selected error value option	Output signal
Error-value ⇳ Minimum (4.0mA)	
Error-value ⇳ Hold last value	
Error-value ⇳ Maximum(20.0 mA)	

Selected error value option	Output signal
Error-value ⇳ Other value ... Error-value 2.00 mA	

Error-value ⇳
Minimum

Select an error-value in the scroll list.

Confirm by pressing **ENTER**.

Error-value:
...

If you have selected OTHER VALUE, enter the error value now. The value must be within the physical limits of the process output.

Confirm by pressing **ENTER**.

Note:	US300PM stores your settings now at the end of the dialogue.

15.1.3 Function Check

Finally, you can test the function of the installed output. Connect the output you have installed with a multimeter.

Test of analogue outputs

I1:Output Test
4 mA

Enter a test value (in our example, the current output is tested). The test value should be in the selected output range. Confirm by pressing **ENTER**.

I1= 4.0 mA
Again? no >YES<

The output functions correctly if the measuring instrument displays the entered value.

Select YES to repeat the test, NO to return to the SYSTEM SETTINGS.

Test of binary outputs

B1:Output Test ⇳
Reed-Relais OFF

In the OUTPUT TEST scroll list, select OFF to test the de-energized state of the binary output. Confirm by pressing **ENTER**.

No current should be flowing at the output now.

```
B1= OFF
Again?  no >YES<
```

Select YES and confirm by pressing **ENTER**.

```
B1:Output Test ⇳
  Reed-Relais ON
```

In the OUTPUT TEST scroll list, select ON to test the energized state of the output. Confirm by pressing **ENTER**.

A current should be flowing now.

```
B1= ON
Again?  no >YES<
```

Select YES to repeat the test, NO to return to the SYSTEM SETTINGS.

15.2 Defining the Error Value Delay

The error value delay is the delay after which US300PM will transmit the error value to the output in case no valid measured values are available.

If you don't want to enter a specific value for the delay, US300PM will use the damping value as error value delay.

If you want to give the error value delay a specific value, activate the ERROR-VAL. DELAY as follows:

```
Error-val.delay
>DAMPING<  edit
```

In the SPECIAL FUNCTION \ SYSTEM SETTINGS program branch, select the DIALOGS/MENUS entry. Confirm by pressing **ENTER**.

In the ERROR-VAL. DELAY display, select DAMPING if you wish the damping factor to be used as error-value delay (default setting). Select EDIT to activate the error value delay inquiry. From now on, US300PM will ask for the error value delay in the program branch OUTPUT OPTIONS.

This setting is coldstart resistant.

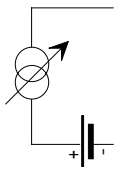
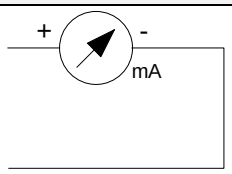
```
Error-val.delay
       10     s
```

This display will appear in the program branch OUPUT OPTIONS later.

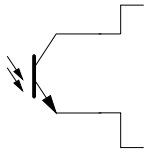
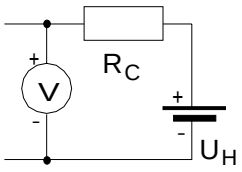
Enter the error-value delay.

Confirm by pressing **ENTER**.

15.3 Circuits of Process Outputs

OUTPUT	US300PM	TERMINAL (socket)	CIRCUIT	
Current output active		Px**+** (red) (black) Px**-**		R_{LOAD} < 500Ω

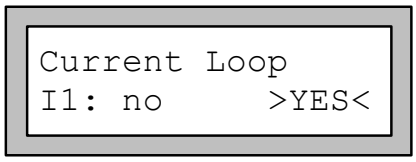
15

OUTPUT	US300PM	TERMINAL (socket)	CIRCUIT	
Binary output Open-Collector		Px**+** (red) (black) Px**-**		U_H = 5...24V R_C[kΩ] = U_H / Ic[mA] Ic = 1...4mA

15.4 Activation of an Analogue Output

15.4.1 Activation of a Current Output

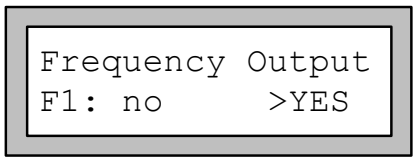
Note:	The display CURRENT LOOP only appears in program branch OUTPUT OPTIONS if a current output has been installed.



Select the OUTPUT OPTIONS program branch for the channel assigned to the output you want to activate. In the CURRENT LOOP display, select YES to activate the current output.

15.4.2 Activation of a Frequency Output

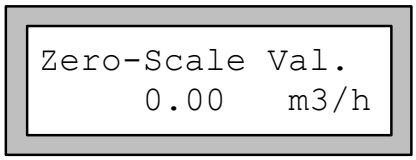
Note:	The display FREQUENCY OUTPUT only appears in the program branch OUTPUT OPTIONS if a frequency output has been installed.



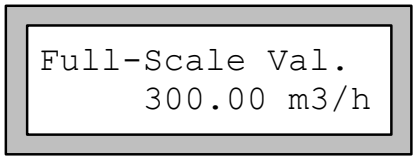
Select the OUTPUT OPTIONS program branch for the channel assigned to the output you want to activate. In the FREQUENCY OUTPUT display, select YES to activate the frequency output.

15.4.3 Scale Values for Analogue Outputs

After you have activated an output in the program branch OUTPUT OPTIONS, US300PM will ask for the scale values for the source item.



Enter as ZERO-SCALE VALUE the lowest measured value expected. The displayed measuring unit is the unit of the selected output source item. The zero-scale value corresponds to the lower limit of the output range.



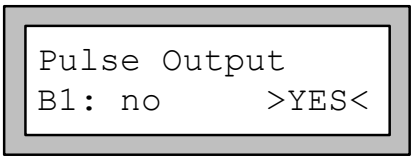
Enter as FULL-SCALE VALUE the highest measured value expected. The full-scale value corresponds to the upper limit of the output range.

Example :

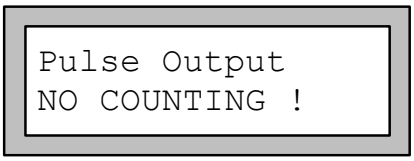
If the output range 4/20 mA was selected for a current output, a signal of 20 mA will be transmitted to the current output when a flow rate of 300 m^3/h is measured. For a measured current of 0 m^3/h, a signal of 4 mA will be transmitted to the current output.

15.5 Activation of a Pulse Output

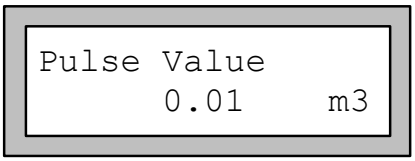
Note:	The display PULSE OUTPUT only appears in the program branch OUTPUT OPTIONS if a pulse output has been installed.



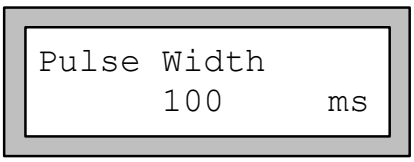
Select the OUTPUT OPTIONS program branch for the channel assigned to the output you want to activate. In the PULSE OUTPUT display, select YES to activate the pulse output.



If the flow velocity is selected as the quantity of measurement, an error message is displayed. The use of the pulse output is not possible because it is technical nonsense to totalize the flow velocity!

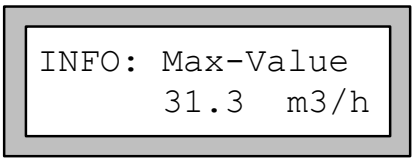


Enter the PULSE VALUE. US300PM automatically displays the units selected for the quantity of measurement in the OUTPUT OPTIONS. When the measuring quantity reaches the pulse value, a pulse will be emitted.



Enter the PULSE WIDTH. Values between 80 and 1000 milliseconds are possible. The pulse width depends on the specifications of the instrument (e.g. counter, totalizer, PLC) which will be connected with the pulse output

US300PM then displays the maximum possible flow in the pipe that the pulse output can work with. This value is calculated from the data given for pulse value and pulse width.



Confirm by pressing **ENTER**.

Attention!	If the actual flow exceeds this 'Max-Value', the pulse output will not function correctly. In such a case, the pulse value and pulse width should be changed to accommodate the flow conditions.

15.6 Activation of an Alarm Output

Note:	The display ALARM OUTPUT only appears in the program branch OUTPUT OPTIONS if an alarm output has been installed.

A maximum of 3 alarm outputs operating independently of each other can be assigned to a measuring channel. The alarm outputs can be used:

- for the output of status information about the ongoing measurement
- or to start and stop control pumps, electrical motors or other equipment.

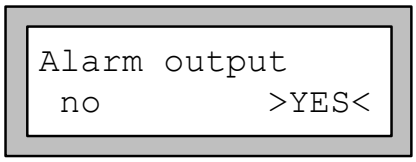
You may assign one of the following functions to each of the alarm output:

Function	Alarm is activated when ...
Upper limit	... the measured value exceeds the upper limit.
Lower limit	... the measured value falls below the lower limit.
Sign-change	... the flow changes direction.
Quantity limit	... a totalizer has reached a predefined limit (e.g. for batch operations)
Error	... no measurement is possible.
No function	The alarm is always de-energized.

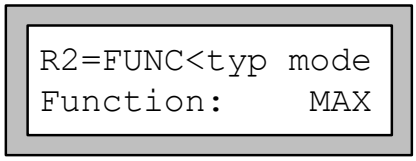
Further settings for the alarm output are:

- the holding behavior (holding/non-holding) and
- the status in idle state (normally open/closed).

Attention: When US300PM is not measuring, all alarms are in de-energized state, independently of the programmed function.



Select the OUTPUT OPTIONS program branch for the channel assigned to the output you want to activate. In the ALARM OUTPUT display, select YES to activate one or several of the installed alarm outputs.



The display that then appears contains tree scroll lists:

FUNC for setting the switching condition,

TYP for setting the alarm's holding behavior,

MODE for setting the alarm's state when idle.

Use keys Q- **4** and **6** Q+ to select an scroll list on the first line.

Use keys Q_{ON} **8** and **2** Q_{OFF} to select the corresponding setting on the second line.

Press **ENTER** to confirm the selected settings at the end of selection.

15.6.1 Setting the Alarm Properties

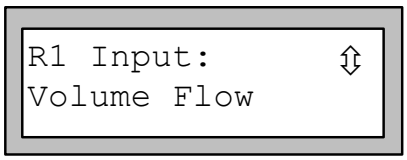
Alarm property	Available settings	Description
FUNC	MAX	Alarm is activated when the measured value exceeds the upper limit.
(switching condition)	MIN	Alarm is activated when the measured value falls below the lower limit.
	+⇨ - -⇨ +	Alarm is activated when the flow changes its direction (sign change of measured value).
	QUANTITY	Alarm is activated when the totalizing function is selected and the totalizer reaches or exceeds the programmed limit (in the flow direction determined by the sign).
	ERROR	Alarm is activated when measurement is impossible.
	OFF	No function, the alarm is always deactivated.

Alarm property	Available settings	Description
TYP (alarm's holding behavior)	NON-HOLD	Alarm returns to idle state after approx. 1 second if the switching condition is not true any more.
	HOLD	Alarm stays activated even if the switching condition is not true any more.
		C During measurement, this key will switch all alarms to their idle state. If the switching condition is still met, however, the alarms will switch back into their activated state after 1 second.
MODE (alarm's state when idle)	NO Cont.	Alarm is energized when the switching condition is true, the alarm is de-energized when idle (NO=normally open).
	NC Cont.	Alarm is de-energized when the switching condition is true, energized when idle (NC=normally closed).
		BRK **ATTENTION:** This key will bring you back to the main menu. All alarms are switched to their de-energized state, independently of their programmed state.

15.6.2 Setting the Limit Values

For the functions MAX and MIN

If you have selected the switching condition MAX or MIN under FUNC, you can input the desired limit values for the alarm outputs as follows:

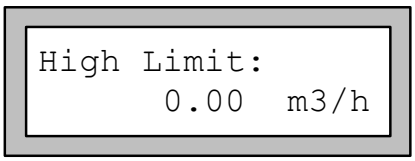


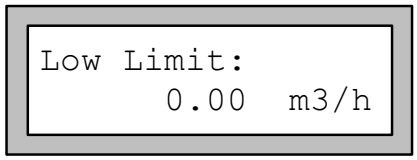
Select in the INPUT scroll list which physical quantity should be used for comparison. Available options are:

- the volume flow,
- the signal amplitude,
- the sound velocity for the medium.

Confirm by pressing **ENTER**.

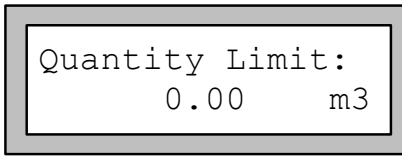
US300PM will then ask for the value of the limit.

Function	Display and comparison	Remarks
MAX	 Comparison: measured value > limit The alarm output switches when the measured value exceeds the programmed limit.	The sign is taken into consideration! *Example:* *High limit = -10.0 m^3/h* *The limit will be exceeded by a measured value of -9.9 m^3/h or +2.5 m^3/h. The alarm won't switch if, for instance, the measured value amounts to -11.0 m^3/h.*

MIN	 Comparison: measured value < limit The alarm output switches when the measured value falls below the programmed limit.	The sign is taken into consideration! *Example:* *Low limit = -10.0 m^3/h* *The limit will be exceeded by a measured value of -11.0 m^3/h or -22.5 m^3/h. The alarm won't switch if, for instance, the measured value amounts to -9.9 m^3/h.*

You can additionally enter a hysteresis for R1 (symmetrically around the limit).

For the function QUANTITY

QUANTITY	 Comparison: total flow quantity ≥ limit The alarm output switches when the total count reaches the programmed limit.	US300PM has a totalizer for each flow direction (positive and negative). If you enter a **positive limit**, the comparison will be made with the totalizer value for positive flow direction. If you enter a **negative limit**, the comparison will be made with the totalizer value for negative flow direction.

Note!	The comparison will also be made if the total flow quantity of the other flow direction has been selected for displaying.

Note:	During measurement, the limit values will always be interpreted in terms of the unit of measurement selected at the time the quantity limit was set. The limit value stays the same even if the quantity and/or unit of measurement is changed. If you change the unit of measurement, also change the quantity limit. *(Example: You have entered a limit value of 60.0 m^3/h, then changed the unit of measurement to m^3/min. You should also change the quantity limit from 60.0 m^3/h to 1.0 m^3/min).*

15.6.3 Apparent Delays when Switching Alarm Outputs

US300PM rounds the measured value and totalizer value with a precision of two decimal places behind the comma before they are displayed. However, US300PM compares the limits with the non-rounded values. This might cause an apparent output switching delay, especially when extremely small changes of the measured value take place (smaller than the equivalent of two decimal places behind the comma). In these cases, remember that the accuracy of the output switching is higher than the accuracy of the display.

15.6.4 Reset and Initialization of the Alarms

- After a coldstart, all alarm outputs will be initialized. They will then be in the following state:

```
FUNC:      OFF
TYPE:      NON HOLD
MODE:      NO CONT.
LIMIT:     0.00
```

- During measurement, pressing key **C** will switch all alarms to their idle state. However, all alarms which switching condition is still met will switch back into their active state after 1 second.
- Pressing **BRK** stops measurement and brings you back to the main menu. All alarms are switched to their de-energized state, independently of their programmed idle state.

15.6.5 Alarm Outputs in the Parameter Record

The configuration of the alarm outputs will be stored with the current parameter record (program branch SPECIAL FUNCTION). Thus, the configuration of the alarm outputs will also be loaded when a stored parameter record is loaded.

15.6.6 Alarm Outputs during Transducer Positioning

When you have confirmed the transducer distance in program branch MEASURING and the positioning of the transducers begins (bar graph display), all alarm outputs switch to their programmed idle state.

When you return to the bar graph display during measurement, the alarm outputs will switch back to their programmed idle state. An alarm output of the type HOLDING which has switched during the previous measurement will remain in its programmed idle state after completion of the transducer positioning if the switching condition is not met any more.

You can obtain the same result by pressing key **C** during measurement. The switching of the alarms into their programmed idle state is not indicated on the display.

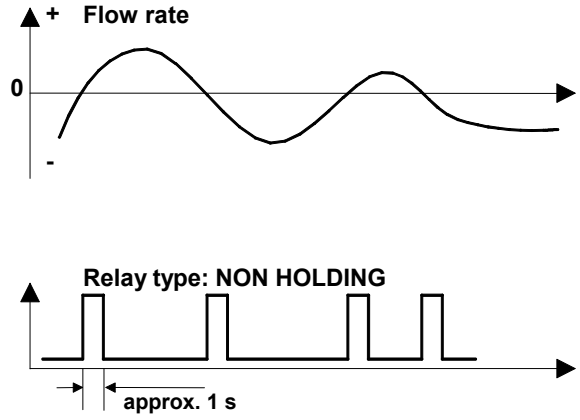
15.6.7 Alarm Output Operation and Update

Alarms with switching condition MAX or MIN will be updated once per second at most in order to avoid 'humming' (a permanently fluctuating measured value around the limit constantly triggering the alarm).

Alarms of type NON-HOLD will switch in their activated state for about 1 second when the switching condition is met.

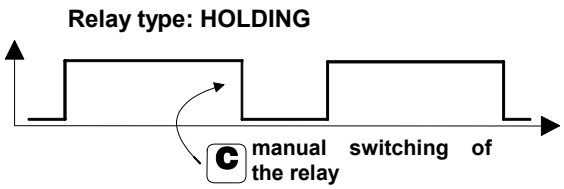
Alarms with switching condition QUANTITY will immediately switch in their activated state when the totalizer value reaches or exceeds the limit.

Alarms with switching condition +⇨- -⇨+ (sign change) and type NON-HOLD will switch in their activated state for about 1 second with any change of flow direction.



Alarms with switching condition +⇨- -⇨+ (sign change) and type HOLD will switch in their activated state with the first change of flow direction and stay in this state.

They can be switched back by pressing C.



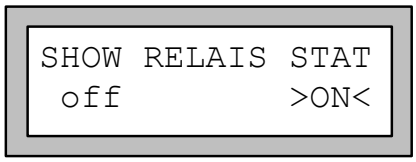
Alarms with switching condition ERROR will only switch in their activated state after several unsuccessful measuring attempts (SIGNAL LED lights red). Therefore, typical short-term disturbances of the measurement as, for example, air bubble caused by pumps being switched on, will not activate the alarm. If the alarms are of type NON-HOLD, they will switch back as soon as a valid measured value is obtained (SIGNAL LED lights green).

If there is an internal adaptation to changing measuring conditions, e.g. to a considerable rise of the medium temperature, the alarm will not switch.

15.6.8 Alarms' State

Note:	There are no visual or acoustic of indicating alarm switching or reset.

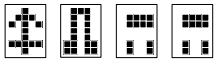
It is possible to have the state of the alarms displayed during measurement. This function can be activated in program branch SPECIAL FUNCTION \ SYSTEM SETTINGS \ DIALOGS/MENUS. This setting is coldstart resistant.



Select the SHOW RELAIS STAT option. Select ON to activate the display of the alarms' state.

During measurement, press key DISP 9 to scroll on the first line of the display until you reach the alarm's state display.

The alarm's state is displayed in the following form:

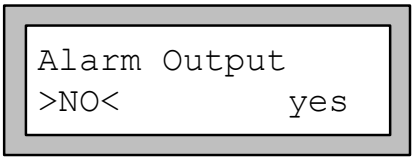
RX = □ □ □ □ where □ represents a pictogram (R1 =  for example).

Pictograms of the alarm's state display

	Nr.		Function	Type	Switching condition	Actual state
R	□	=	□	□	□	□
	1		no function	NON-HOLD	NO (normally open)	CLOSED
	2		MAX	HOLD	NC (normally closed)	OPEN
	3		MIN			
			+ →- - →+			
			QUANTITY			
			ERROR			

15.7 Deactivating an Alarm Output

If you no longer require a programmed alarm output, it can be deactivated. The current settings of the output (high limit, low limit, etc...) are stored and will be available when the output is re-activated.



Deactivate the outputs by selecting NO in the display of the corresponding output in the program branch OUTPUT OPTIONS.

16 Troubleshooting

Select in the following list the situation corresponding the best to your problem and refer to the corresponding section.

- An error message was displayed.

  Consult section 16.1.

- Measurement is impossible. No signal is detected.

  Consult section 16.3.

- The measured values substantially differ from the expected values.

  Consult section 16.4.

- US300PM doesn't react anymore.

  Consult section 16.2.

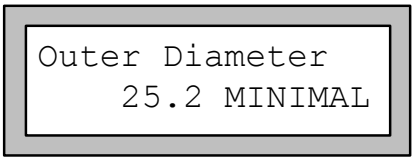
If any trouble appears which cannot be solved with the help of this chapter, please contact your local Yokogawa sales offices, giving a precise description of the problem. When contacting Yokogawa, always have the following information at hand: the model (MODEL) of the instrument, its serial numer (No.), its factory number (F-No., see section 11.5) and the number of the firmware version (see section 11.5).

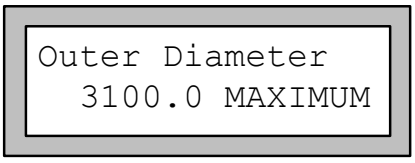
16.1 Error Messages

This section contains an overview of error messages you might encounter. We describe their causes, give possible reasons for their occurrence and also try to make suggestions as to how these problems can be overcome.

16.1.1 Errors during Parameter Input

Error messages F1 and F2:





Reason:

The entered outer diameter value is not compatible with the inner diameter range of the connected transducers.

Corrective action:

If the entered outer diameter is incorrect, enter the correct value in the program branch PARAMETER.

If the outer diameter really surpasses the given limit, consult your local Yokogawa sales office for advice.

Error message F3:

Reason:

The inner diameter, which is calculated by US300PM from the entries for wall thickness and outside diameter, is smaller than the minimum value allowed.

Corrective action:

Check if the values of outside pipe diameter and wall thickness are correct in program branch PARAMETER.

You might have corrected the outside pipe diameter without taking the wall thickness into consideration.

Error message F4:

Reason:

There are parameters missing in program branch PARAMETER, no complete parameter record exists.

Corrective action:

Enter any parameters not yet entered.

Error message F5:

Reason:

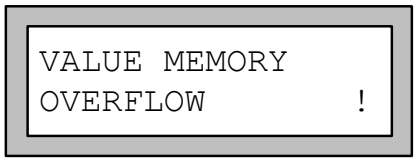
No complete parameter record exists. Storage is impossible.

Corrective action:

Enter the missing parameters.

16.1.2 Errors during Measurement

Error message F6:



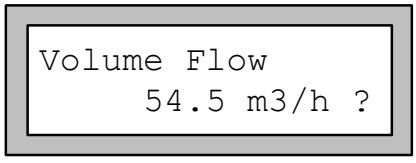
Reason:

US300PM interrupts the measurement when there is not enough free internal memory available. The measurement will not be interrupted if an output has been activated. In this case, the error message appears periodically on the display.

Corrective action:

Deactivate the output option STORE MEAS. DATA (section 8.1.1). Output the stored measured values via the serial interface. Afterwards, you can delete them (see section 8.6).

Error message F7:



A **question mark** appears at the right side of the lower display line.

SIGNAL LED is red.

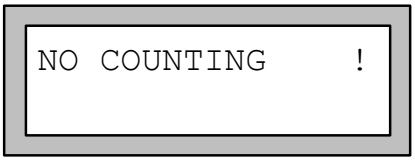
Reason:

The question mark signals that there is insufficient acoustic contact during the measurement. The measurement is erroneous. The last correct measured value remains on the display.

Corrective action:

See section 16.3.

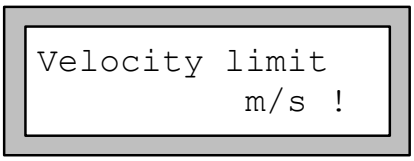
Error message F8:



Reason:

You have tried to activate the totalizers although flow velocity was selected as the quantity of measurement. This quantity of measurement cannot be totalized.

Error message F9:



An **exclamation mark** appears at the right side of the lower display line.

SIGNAL LED is red.

Reason:

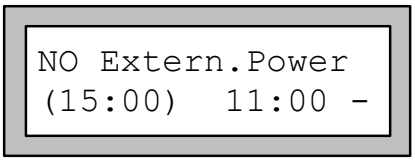
The exclamation mark signals that the defined upper limit for the flow velocity has been surpassed. All values of flow velocities greater than this limit are marked as outliers ('invalid measured value' or 'measurement impossible').

Corrective action:

1. Wait until the disturbances that cause the high velocities in the pipe disappear.
2. If necessary, consider the input of a new upper limit or deactivate the velocity check (section 7.3).
3. Look for a more suitable measuring point.

16.1.3 Errors concerning the Battery

Error message F10:



Reason:

The power supply was interrupted while charging.

Corrective action:

Reconnect the external power supply. US300PM will continue the charging process for the remaining charging time.

Error message F11:

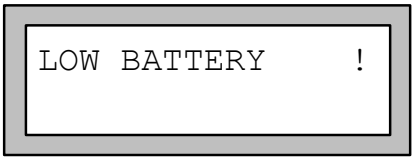
Reason:

You have activated the battery charging process although there is no external power supply connected to US300PM.

Corrective action:

Supply US300PM with external power.

Error message F12:



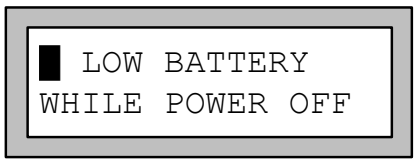
Reason:

This message appears when the battery is low, but still has enough capacity for the display and keyboard operation in order to store the current parameter record. However, a low battery will not allow the undertaking of measurements.

Corrective action:

Acknowledge this message by pressing **ENTER**. The message appears every minute for five seconds. Charge the battery (see section 11.6).

Error message F13:



Reason:

When this error message is shown after powering up US300PM, the instrument switched itself off because of a low battery.

Corrective action:

Acknowledge this message by pressing **ENTER**. The message appears every minute for five seconds. Charge the battery (see section 11.6).

16.1.4 Errors when Working with Parameter Records

Error message F14:

Reason:

The display DELETE PAR. REC. of the program branch SPECIAL FUNCTION was selected although no parameter records exist.

Corrective action:

This message is for information only. Press **ENTER** to return to the main menu.

16.1.5 Errors during Data Transfer

Error message F16:

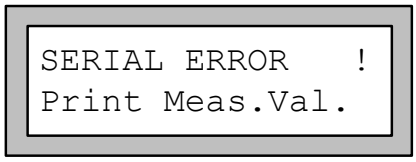
Reason:

The special function PRINT MEAS. VAL. was activated although no measured values are stored in US300PM.

Corrective action:

Activate STORE MEAS. DATA and repeat measurement.

Error message F17:



Reason:

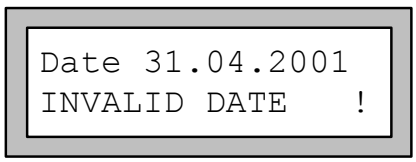
There is a problem with the serial communication.

Corrective action:

Check connections and make sure that the connected instrument is ready to receive data.

16.1.6 Error Messages during Date/Time Setting

Error message F18:



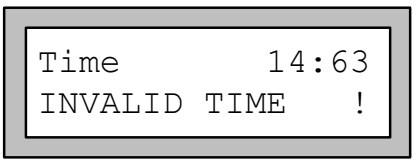
Reason:

The date was not entered correctly.

Corrective action:

Enter a valid date.

Error message F19:



Reason:

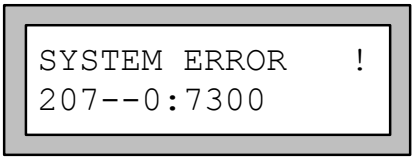
The time was not entered correctly.

Corrective action:

Enter a valid time.

16.1.7 System Errors

Error message F20:



(Number sequence is an example.)

Reason:

Unexpected system error.

Corrective action:

Press **BRK** to return to the main menu.

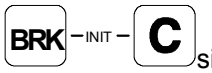
Should this message appear several times, please note the factory number of your instrument and the number sequence in the lower line of the display. Contact your local Yokogawa sales office for further assistance.

16.2 US300PM doesn't react anymore

Restart the instrument by pressing following keys simultaneously:

If the problem occurs again:

Did you change any parameter and settings before the problem occurred? Incorrect parameter and setting values can lead to system errors. Try finding out the last changes made and reset the parameter/setting to their initial value.

Pressing keys 

simultaneously while switching the flowmeter ON until the main menu appears will initialize US300PM. Most parameters and settings are reset to the factory default values. The memory will not be cleared.

If the problem still occurs, contact your local Yokogawa sales office.

16.3 No signal can be detected

a) Signal Loss

Problem:

A **question mark** appears on the lower display line, at the right of the last measured value. The SIGNAL LED is red.

Check:

- Wait a little while until the acoustic contact is established again. Temporarily, there might be a higher proportion of gaseous or solid particles in the flowing medium.
- Make sure there is a film of acoustic coupling compound between the transducers and pipe wall. Renew the film if necessary. Position the transducers again. Adjust transducers for maximum acoustic contact.

- Measure with a smaller number of transit paths. The signal attenuation might be too high because of high fluid viscosity or deposits on the inner pipe wall.
- Select a more suitable measuring point along the pipe work (see section 5.1).

b) No Signal

Problem:

No value appears on the display. A **question mark** is displayed on the lower line. The signal LED is red.

Check:

- Were the parameters of the pipe and of the medium entered correctly and completely? You should especially control if the entered sound velocity is correct.
- Are the transducers positioned correctly? (calculated distance ± 3 mm; see section 5.7.1)
- Is the surface of the pipe clean, free of paint, rust, etc.? Make sure there is a film of acoustic coupling compound between the transducers and pipe wall. Renew the film if necessary.
- Select a smaller number of transit paths. The signal attenuation might be too high because of high fluid viscosity or deposits on the inner pipe wall.
- Select a more suitable measuring point along the pipe work (see section 5.1).
- Is the pipe filled completely? (see section 5.1.3)
- Is the proportion of gas bubbles or solid particles in the flowing medium too high? Particles scatter and absorb ultrasounds and therefore attenuate the signal. Measurement is impossible if the proportion of solid particles or gas bubbles is of 10 % or more. If the latter is less than 10 %, measurements might be possible under certain conditions.
- Are there deposits on the inner pipe wall? These deposits might attenuate too heavily the ultrasonic signal.
- Is the pipe lined? Lined pipes may cause measurement difficulties if the lining is not bonded correctly to the pipe wall or consists of a material which has bad acoustic characteristics. Try measuring on another section of the pipework or contact your local Yokogawa sales office.
- What is the pipe on which you measure made of? Measurements on porous pipe materials (e.g. concrete or cast iron) are only possible under certain conditions. Contact your local Yokogawa sales office.
- How big is the viscosity of the medium? Media with high viscosity strongly attenuate the ultrasonic signals. Measurements on media with viscosity values of more than 1000 mm2/s are only possible under certain conditions. Contact your local Yokogawa sales office.
- Are the transducer used appropriate for your application?
- Is the temperature maybe too high (higher than 130°C for transducers for medium temperatures for example)?

16.4 Measuring Data Substantially Differ from the Expected Values

- Is the sound velocity entered for the medium correct? A wrong value of the sound velocity could lead you to identify the ultrasonic signal that was reflected on the pipe wall as the measuring signal. The measured flow rate would then always be very small or fluctuate around zero.
- Is the defined upper limit for the flow velocity maybe too low? The measured flow velocities that are greater than the defined upper limit are ignored and marked as outlier. All quantities derived from the flow velocity are equally ignored. If most measured values are higher than the upper limit, the totalized values (the volume flow rate for example) will be too small. See section 7.3.

- Is the defined cut-off flow maybe too high? All flow velocities below the cut-off are set to zero. All quantities derived from the flow velocity are equally ignored. If most measured flow velocities are below the cut-off flow velocity, US300PM will display a flow rate of zero most of the time, and the totalized values will always be too small. See section 7.4.
- Check the set pipe roughness, see section 5.3.5.
- Is the distance between the measuring point and disturbance sources in the pipe too small? (distances between measuring point and disturbance source, see section 5.1.2)
- Is the flow velocity below the measuring range limit of 0,01 m/s? (see specifications in Appendix A.)

If the measured values are still wrong after these controls, contact your local Yokogawa sales office.

A Standard Specifications

US300PM

• General

Fluid:	Liquid (Turbidity < 10,000 mg/L, fluid sound speed 800 to 3500m/s)
Measured:	Volume flow, mass flow (by setting density), flow velocity, sound speed in the fluid Wall thickness of the pipe (when optional wall thickness probe is available)
Measuring principal:	Transit time method using ultrasonic signal
Pipe size:	25 to 6500 mm
Pipe and lining material:	Carbon steel, Stainless steel, Grey cast iron, Ductile iron, Copper, Glass, PVC, etc
Flow velocity range:	0.01 to 25 m/s
Resolution:	0.025 cm/s
Accuracy:	1 to 3% of reading depending on application (flow velocity > 0.8m/s) 0.008m/s (flow velocity =< 0.8m/s) (depends on the flow profile)
Measuring cycle:	100 to 1000 Hz (when only one channel input)
Straight pipe run in the upstream:	10 to 50 diameters, depending on the kind of the flow disturbance

• Ultrasonic flowmeter (US300PM)

Construction:	
Housing material:	Aluminium (powder coated)
Water and dustproof:	IP54 (EN60529) IPx4 (JIS C 0920)
Dimensions:	115 x 276 x 268mm (excluding a handle)
Weight:	approx. 3.9 kg (incl. battery set)
Input:	
Number of input channels:	2 (Cannel A, Channel B) Both transducers and wall thickness probe can be connected freely
Output:	
Current output:	0 to 2 outputs Range: 4 to 20mA Flow velocity, volume flow, or sound speed in the liquid can be freely assigned
Frequency output:	0 to 1 output Range: 0 to 1kHz Contact type: Open-collector 24V/4mA The value indicates instantaneous flow rate.
Binary output : (pulse or alarm)	0 to 2 outputs Contact type: Open-collector 24V/4mA The output values are selectable for each output. The pulse outputs indicate the total volume flow (0.01 to 1000/unit) with pulse width 80 to 1000 ms.
Terminal type:	Banana plug terminals (+, -)
Display and Setting:	
LCD display:	2x16 characters LCD with back light that can be stitched on or off. Two values can be displayed at the same time.
LED lamp:	SIGNAL lamp: Indicates the status of the measuring signal from each input channel (green or red light) BATTERY lamp: Indicates the status of battery voltage, etc.
Keyboard:	15 keys (numeric and function keys) Easy operation by some guidance on the LCD
Display language:	Following languages selectable: Czech, Danish, Dutch, English, French, German, Norwegian, Polish, Turkey

Parameter setting storage function:

Function:	Storage of pipe and fluid parameters (Maximum 80 different settings) Storage of all parameters (Maximum 14 different settings)
Calculation function:	
Flow value:	Flow velocity Volume flow or mass flow rate and totalization (both positive and negative flow totalization)
Sound velocity:	Sound velocity in the fluid

Wall thickness:	Wall thickness of the pipe possible using Wall thickness probe (optional).
	Transfer function of the measured thickness to the pipe parameter
Calculation for the two flow inputs:	Two values from average, sum, or difference of the channel A and channel B inputs are available freely
Output assignment:	Calculated values above except for the wall thickness can be freely assigned to the actual outputs (two channel independent outputs available)
Output damping:	0 to 100 seconds
Alarm:	
Alarm items:	Upper limit, lower-limit, flow direction change, quantity limit (for batch operation), error (measurement impossible)
Output hold type:	Non-hold or Hold
Output contact direction:	Normal Open or Normal Close
Data logging function (for maintenance purpose only):	
Function:	Store measured values in the internal memory
Memory size:	27,000 values (standard)
	100,000 values (optional)
	(Note) About 3,000 values of them are for internal data use
Communication function (for maintenance purpose only):	
Type:	RS 232
	(Cross Cable)
Connector:	D-sub 9-pin connector, male
Function:	On-line/Off-line output of the measured values to personal computers
Time-programmable measurement function:	
Function:	Automatic start and stop of the measurement using internal clock.
	Can be used with data logging function or communication
Power supply:	
Power supply voltage:	Internal rechargeable battery (6V/4Ah) or power supply adapter (100 to 240VAC input, used also as battery charger)
Battery operating time:	Maximum 14 hours
Power consumption:	less than 15W

Safety and EMC standard:	
General safety:	EN61010 (CE marking)
EMC regulation:	EN61326 (CE marking)
	AS/NZS 2064 (C-Tick mark)
Operating conditions:	
Ambient temperature:	-10 to +60 deg C

• Transducers (US300PT)

Type of usage:	
Dust and waterproof:	General purpose: IP65 (EN60529) , IPx5 (JIS C 0920)
	Waterproof: IP67 (EN60529), IPx7 (JIS C 0920)
Pipe size type:	Medium size: 25 to 400 mm
	Large size: 100 to 2500 mm
	Very large size: 2000 to 6500 mm
Fluid temperature:	General temp. type: -30 to +130 deg C
	High temp. type: -30 to +200 deg C
Construction:	
Case material:	Stainless steel
Contact surface material:	General temp. type: PEEK (Poly Ether Ether Keton)
	High temp. type: Polyimid
Cable protection material:	Stainless flexible tube
Sensor block size:	18 x 42.5 x 21.5 mm (Medium pipe size type)
	30 x 60 x 33.5 mm (Large and very large pipe size type)
Length of the cable part : (from sensor block to terminal box)	3.0m (Medium pipe size type)
	4.4m (Large pipe size type)
	12.0m (Very large pipe size type)
Weight:	approx. 0.6 kg (Medium pipe size type)
	approx. 1.2 kg (Large pipe size type)
	approx. 2.2 kg (Very large pipe size type)
Optional extension cable (US300PC):	
Length:	5m, 10m, 20m

- **Wall thickness probe**

Type of usage:
Fluid temperature: General temp. type: -20 to +60 deg C
(option /WTG or model USPA301)
High temp. type: 0 to +200 deg C
(option /WTH or model USPA302)
Rating:
Measuring range: 1.0 to 200 mm (This depends on the material)
Resolution: Resolution:
Construction:
Weight: General temp. type: approx. 172g
(option /WTG or model USPA301)
High temp. type: approx. 190g
(option /WTH or model USPA302)

- **Accessories**

Standard accessories for US300PM:
Transportation case
Manual
Measurement tape
Battery set (built-in in the main unit)
Others (fixing hardware, couplant, etc):
Some are selectable in the model and suffix code (see next page) of the main unit or transducers, or separate orders are also possible

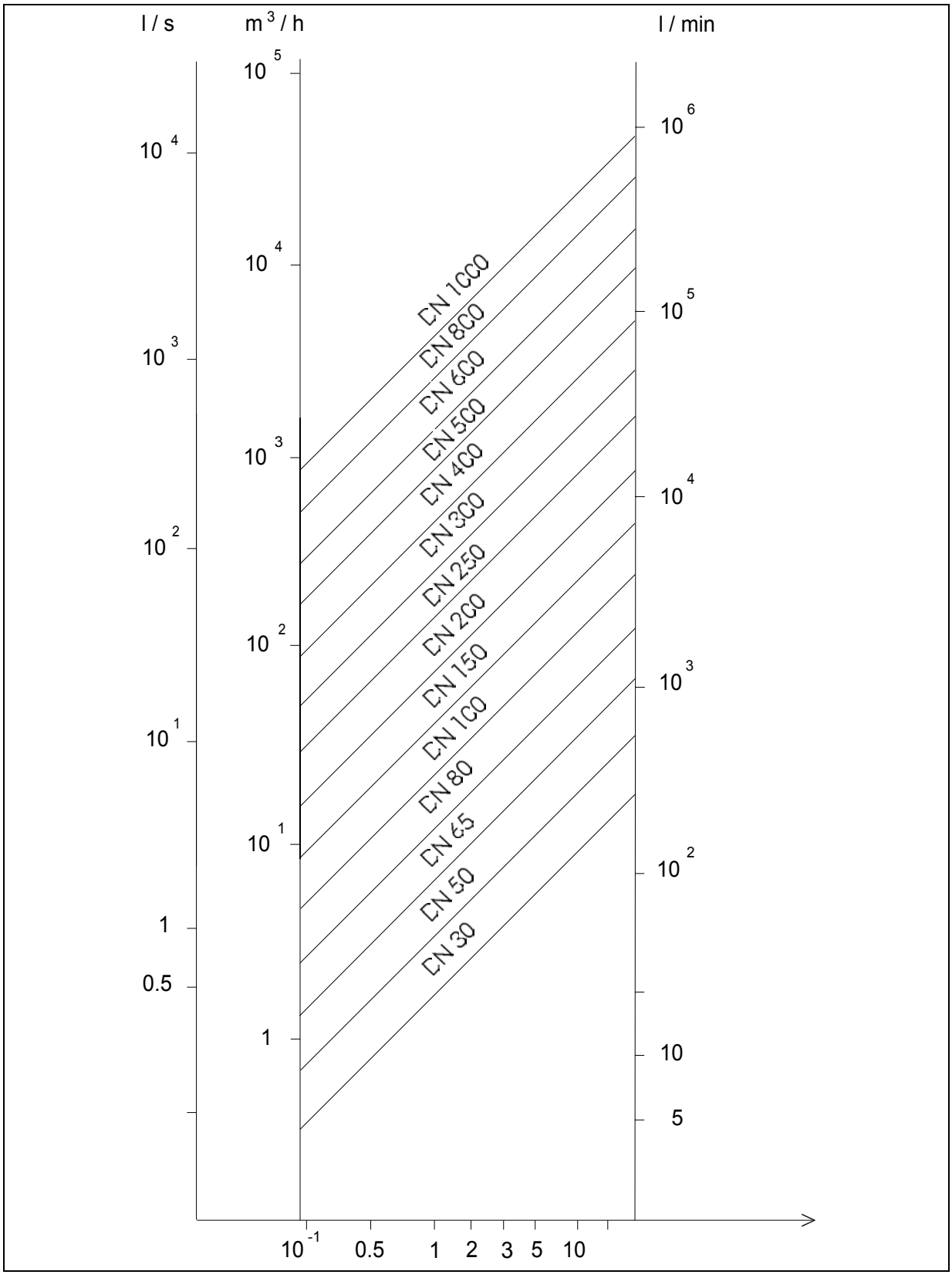
Units of Measurement

Volume flow	Flow velocity	Mass flow	Totalizers		Sound velocity
			Volume	Mass	
m3/h	m/s	g/s	m3	g	m/s
m3/min	inch/s	t/h	l	kg	
m3/s		kg/h	gal	t	
l/h		kg/min			
l/min					
l/s					
USgph					
USgpm					
USgps					
bbl/d					
bbl/h					
bbl/m					

1 gallon [US] = 3.78 l; 1 barrel = 42 gallons = 158.76 l

Flow Nomogram

Volume flow rate



Model and Suffix Code

Ultrasonic flowmeter, portable type

Model	Suffix code		Specification
US300PM			Ultrasonic flowmeter, portable type
Output	-A0		No current output
	-A1		One current output
	-A2		Two current outputs
Power Supply Adapter and AC cable	1		Japan
	2		USA
	3		Europe
	-2		Always 2
	-N		Always N
Option		/PU1	One binary output (pulse or alarm, OC)
		/PU2	Two binary outputs (pulse or alarm, OC)
		/FQ1	Frequency output (OC, 0 to 1 kHz)
		/DLX	Data logging extension (100,000 values)
		/BGT	Tag number on the nameplate (in the nameplate label, maximum 16 characters)
		/WTG	Wall thickness probe (-20 to 60°C)
		/WTH	Wall thickness probe (0 to 200°C)

Note: Option /PU1 and /PU2 are exclusive.

Optional extension cable for portable type

Model	Suffix code	Specification
US300PC		Optional extension cable for portable type
Length	-A005	Cable length 5 m
	-A010	Cable length 10 m
	-A020	Cable length 20 m

Transducers for portable type

Model	Suffix code		Specification
US300PT			Transducers for portable type
Usage	-G		General purpose (IP65)
	-W		Waterproof (IP67)
Pipe Size / Fluid Temperature	BG		Medium & General (with 3m cable)
	BH		Medium & High (with 3 m cable)
	CG		Large & General (with 4.4 m cable)
	CH		Large & High (with 4.4 m cable)
	DG		Very large & General (with 12 m cable)
			(Note) B: Medium size (25 to 400 mm) C: Large size (100 to 2500 mm) D: Very large (2000 to 6500 mm) G: General temperature (-30 to 130°C) H: High temperature (-30 to 200 °C)
Mounting fixture	-S		Standard type (set of two blocks, including ruler marked length 330 mm)
	-M		Magnetic type for general temp. (-30 to 100°C, set of two blocks, including ruler marked length 330 mm)
	-N		None
Fixing chain	B		For 25 to 1200 mm Fixing chains (1 x 2) Extensional fixing chains (1 x 2)
	C		For 1200 to 3000 mm Fixing chains (1 x 2) Extensional fixing chains (4 x 2)
	D		For 3000 to 6500mm Fixing chains (1 x 2) Extensional fixing chains (10 x 2)
	N		None
Acoustic couplant	G		General type (-30 to 130°C)
	H		High temperature type (-30 to 200°C)
	N		None
Option		/TTP	Transducer tag plate (max. 16 characters)

Accessories (for the ultrasonic flowmeter US300PM)

Accessories	Model	Description
Wall thickness probe	USPA301	Wall thickness probe (-20 to 60°C)
	USPA302	Wall thickness probe (0 to 200°C)
Power supply adapter	USPA311	Power supply adapter
AC cable with plug	USPA321	Japan
	USPA322	USA
	USPA323	Europe
	USPA324	United Kingdom
	USPA325	Australia
	USPA326	South Africa
Battery set	USPA331	Battery set (6V 4Ah)
Transport case	USPA341	Transportation case

Accessories (others)

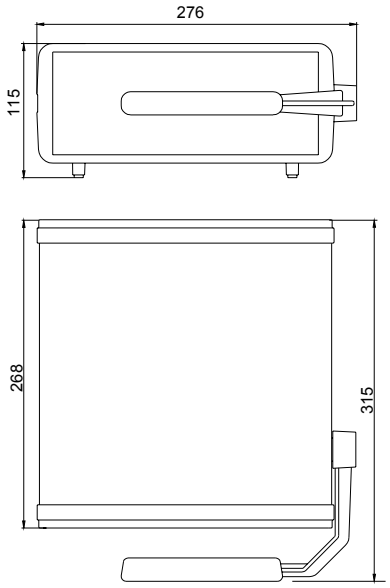
Accessories	Model	Description
RS 232 cable	USPA401	RS 232 cable
RS232 adapter 9/25	USPA402	RS232 adapter 9/25
Measuring tape	USPA411	Measuring tape

Accessories (for the transducers US300PT)

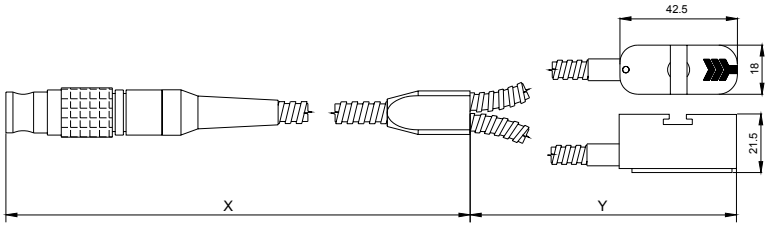
Accessories	Model	Description
Fixing strap	USPA001	Fixing strap of 10 m length
	USPA002	Fixing strap of 20 m length
Fixing clip	USPA011	Two fixing clips of medium type (for pipe size 40 to 100 mm)
	USPA012	Two fixing clips of large type (for pipe size 100 to 6500 mm)
Fixing band	USPA021	Fixing band for transducers of type B (only for pipe size 25 to 50 mm)
Fixing chain	USPA031	Fixing chain (for pipe size 25 to 600 mm)
	USPA032	Extensional fixing chain (2m length, equal to +600 mm diameter)
	USPA033	Repair set for fixing chain
Mounting fixture	USPA054	Mounting fixture standard type for transducers type B (set of two blocks)
	USPA055	Mounting fixture magnetic type for transducers type B (set of two blocks)
	USPA057	Mounting fixture standard type for transducers type C or D (set of two blocks)
	USPA058	Mounting fixture magnetic type for transducers type C or D (set of two blocks)
Additional magnets for mounting fixture	USPA073	Additional set of two magnets for mounting fixture for transducers type B
	USPA075	Additional set of two magnets for mounting fixture for transducers type C or D
Ruler for mounting fixture	USPA081	Ruler for the mounting fixture (marked length 120 mm)
	USPA082	Ruler for the mounting fixture (marked length 330 mm)
Acoustic couplant	USPA091	Acoustic couplant (100 g, for –30 to 130°C)
	USPA092	Acoustic couplant (100 g, for –30 to 200°C)

Dimensional Drawings

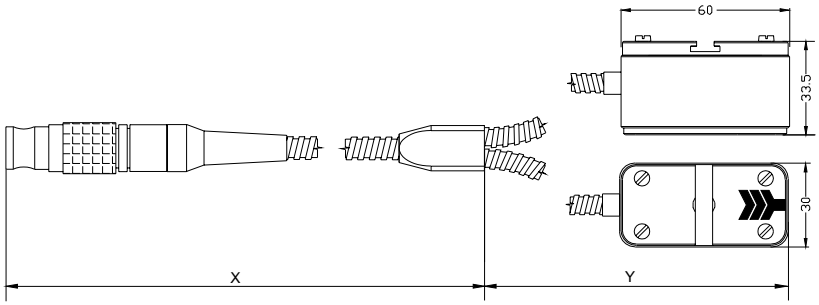
Ultrasonic flowmeter US300PM



Transducers US300PT-xBx



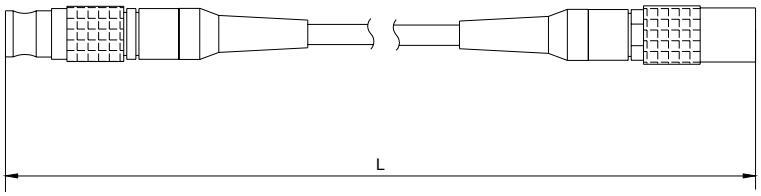
Transducers US300PT-xCx, US300PT-xDx



Length:

Transducer	X (m)	Y (m)	X+Y (m)
US300PT-xBx	2.0	1.0	3.0
US300PT-xCx	2.0	2.4	4.4
US300PT-xDx	5.0	7.0	12.0

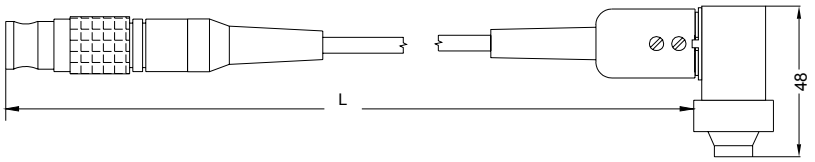
Optional extension cable US300PC-Axxx



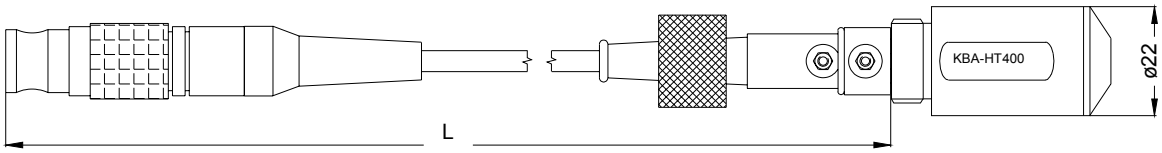
Length:

Optional extension cable	L (m)
US300PC-A005	5.0
US300PC-A010	10.0
US300PC-A020	20.0

Wall thickness probe (for –20 to 60°C)
(option /WTG or model USPA301)



Wall thickness probe (for 0 to 200°C)
(option /WTH or model USPA302)



Length:

Wall thickness probe	L (m)
/WTG or USPA301	1.5
/WTH or USPA302	1.2

B Reference

The content of the tables has been compiled to help the user. The accuracy of the given data depends on the composition and on the manufacturing process of the respective material, as well as on temperature. Yokogawa does not accept liability for possible inaccuracies.

Table 1: Sound velocity of some current pipe and lining materials at 20°C

You will find here the longitudinal and transversal sound velocities of some pipe and liner materials at 20°C. The gray underlayed values are not stored in the US300PM data bank. In the $\mathbf{c_{flow}}$ column, the sound velocity (longitudinal or transversal) used by US300PM for flow measurement is indicated. In the case of your particular measurement problem, remember that the sound velocity depends on the composition and on the manufacturing process of the material. The sound velocity of alloys and cast material will fluctuate over a certain range, the velocity given here should in such a case be understood as an orientation value.

Material	c_{trans} [m/s]	c_{long} [m/s]	c_{flow}	Material	c_{trans} [m/s]	c_{long} [m/s]	c_{flow} [m/s]
Aluminum	3100	6300	trans	Platinum	1670		trans
Asbestos cement	2200		trans	Polyethylene	925		trans
Bitumen	2500		trans	Polystyrene	1150		trans
Brass	2100	4300	trans	PP	2600		trans
Carbon steel	3230	5800	trans	PVC		2395	long
Copper	2260	4700	trans	PVC hard	948		trans
Cu-Ni-Fe	2510		trans	PVDF	760	2050	long.
Ductile iron	2650		trans	Quartz glass	3515		trans
Glass	3400	4700	trans	Rubber	1900	2400	trans
Grey cast iron	2650	4600	trans	Silver	1590		trans
Lead	700	2200	long	Sintimid		2472	long
PE		1950	long	Stainless steel	3230	5790	trans
Perspex	1250	2730	long	Teka PEEK		2537	long
PFA		1185	long	Tekason		2230	long
Plastic	1120	2000	long	Titanium	3067	5955	trans

Table 2: Typical roughness coefficients for pipes

For your convenience, we have already pre-programmed common roughness coefficients for pipe materials. The data are based upon experience with measurements performed with these pipe materials.

Pipe wall material	Absolute roughness [μm]			Pipe wall material	Absolute roughness [μm]		
Drawn pipes of non-ferrous metal, glass, plastics and light metal	0	to	1.5	Cast iron pipes			
Drawn steel pipes	10	to	50	• bitumen lining	120	to	
fine-planed, polished surface	up to	to	10	• new, without lining	250	to	1000
planed surface	10	to	40	• rusted	1000	to	1500
rough-planed surface	50	to	100	• encrusted	1500	to	3000
Welded steel pipes, new	50	to	100				
long usage, cleaned	150	to	200				
lightly and evenly rusted	up to	to	400				
heavily encrusted	up to	to	3,000				

Table 3: Typical properties of media at T=20°C and p=1 bar

Medium	Sound velocity [m/s]	Kinematic viscosity [mm^2/s]	Density [g/cm^3]
30% Glycol / H_2O	1671	4,0	1,045
50% Glycol / H_2O	1704	6,0	1,074
80% Sulphuric acid	1500	3,0	1,700
96% Sulphuric acid	1500	4,0	1,840
Acetone	1190	0,4	0,790
Ammonia	1660	1,0	0,800
Petrol	1295	0,7	0,880
BP Transcal LT	1415	13,9	0,740
BP Transcal N	1420	73,7	0,750
$CaCl_2$ -15 C	1900	3,2	1,170
$CaCl_2$ -45 C	2000	19,8	1,200
Cerium solution	1570	1,0	1,000
Ethyl ether	1600	0,3	0,716
Glycol	1540	17,7	1,260
H_2O-Ethan.-Glyc.	1703	6,0	1,000
HLP32	1487	77,6	0,869
HLP46	1487	113,8	0,873
HLP68	1487	168,2	0,875
ISO VG 22	1487	50,2	0,869
ISO VG 32	1487	78,0	0,869
ISO VG 46	1487	126,7	0,873
ISO VG 68	1487	201,8	0,875
ISO VG 100	1487	314,2	0,869
ISO VG 150	1487	539,0	0,869
ISO VG 220	1487	811,1	0,869
Copper sulphate	1550	1,0	1,000
Methanol	1121	0,8	0,791

Medium	Sound velocity [m/s]	Kinematic viscosity [mm^2/s]	Density [g/cm^3]
Milk	1482	5,0	0,000
Milk 0.3% fat	1511	1,5	1,030
Milk 1.5% fat	1511	1,6	1,030
Milk 3.5% fat	1511	1,7	1,030
Oil	1740	344,8	0,870
Quintolubric 200	1487	69,9	0,900
Quintolubric 300	1487	124,7	0,920
R134 Freon	526	1,0	1,000
R22 Freon	563	1,0	1,000
Hydrochloride acid 37%	1520	1,7	1,200
Sour cream	1550	50,0	1,000
Shell Thermina B	1458	74,5	0,863
SKYDROL 500-B4	1387	21,9	1,057
Toluene	1305	0,6	0,861
Vinyl chloride	900	0,0	0,970
Water	1482	1,0	0,999
Zinc powder suspension	1580	1,0	1,000
Tin chloride suspension	1580	1,0	1,000

Table 4: Chemicals to which Autotex (keypad) is resistant

Autotex is resistant (acc. to DIN 42 115, part 2) to following chemicals for a contact time of more than 24 hours without visible modification:

Ethanol Cyclohexanol Diacetone alcohol Glycol Isopropanol Glycerine Methanol Triacetin Dowandol DRM/PM	Formaldehyde 37%-42% Acetaldehyde Aliphatic hydrocarbons Toluol Xylol Diluent (white spirit)	1,1,1-Trichlorethane Ethyl acetate Diethyl ether N-butyl acetate Amyl acetate Butylcellosolve Ether
Acetone Methyl-ethyl-ketone Dioxan Cyclohexanone MIBK Isophorone	Formic acid <50% Acetic acid <50% Phosphoric acid <30% Hydrochloric acid <36% Nitric acid <10% Trichloroacetic acid <50% Sulphuric acid <10%	Chlornatron <20% Hydrogen peroxide<25% Potash soft soap Detergent Tensides Softener Iron chlorides ($FeCl_2$) Iron chlorides ($FeCl_3$) Dibutyl Phthalat Dioctyl Phthalat Sodium carbonate
Ammonia <40% Natronlauge <40% Potassium hydroxide <30% Alcalicarbonate Bichromate Potassium hexacyanoferrates Acetonitrile Sodium bisulfate	Drilling emulsion Plane fuel Diesel oil Gasoline Varnish Water Paraffin oil Salted water Castor oil Silicone oil Turpentine oil substitute Dccon	

Autotex is resistant (acc. to DIN 42 115, part 2) to acetic acid for a contact time of less than 1 hour without visible damage.

Table 5: Chemicals to which Autotex (keypad) is not resistant

Autotex is not resistant to following chemicals:

Concentrated mineral acids Concentrated alkaline solutions High pressure steam over 100°C	Benzyl alcohol Methylene chloride

Table 6: Properties of water with pressure p = 1000 hPa (1 bar) and saturation

T (°C)	p (10^5 Pa)	ρ (kg m^{-3})	c_P (kJ kg^{-1} K^{-1})
0	1	999.8	4.218
10	1	999.7	4.192
20	1	998.3	4.182
30	1	995.7	4.178
40	1	992.3	4.178
50	1	988.0	4.181
60	1	983.2	4.184
70	1	977.7	4.190
80	1	971.6	4.196
90	1	965.2	4.205
100	1.013	958.1	4.216
120	1.985	942.9	4.245
140	3.614	925.8	4.285
160	6.181	907.3	4.339
180	10.027	886.9	4.408
200	15.55	864.7	4.497
220	23.20	840.3	4.613
240	33.48	813.6	4.769
260	46.94	784.0	4.983
280	64.20	750.5	5.290
300	85.93	712.2	5.762
320	112.89	666.9	6.565
340	146.05	610.2	8.233
360	186.75	527.5	14.58
374.15	221.20	315.5	∞

T Temperature

p Pressure

ρ Density

c_p Specific heat at constant pressure

Index

Alarm outputs 101
  limit values 103
  properties 102
Alarms' state 106
Applications 12
AutoMux 38
Battery 14
  charging 77
  handling 9
  LED 19
  replacement 8
  storage 9
Cleaning 8
Clock, setting 71
Coefficient storage 67
Coldstart 16
Contrast, setting 76
Cut-off flow 43
Damping factor 41
Data logger 49
Date, setting 71
Deleting measured values 53
Density of the medium 28
Description of the flowmeter 11, 13
Dimensional drawings 123
Display 18, 38
Displaying the results 38
Distance to disturbance sources 22
Disturbances 22
Error messages 109
Error value 97
Error value delay 99
Factory number 76
Firmware version 76
Flow direction 35
Flow nomogram 120
Flow profile 21
Flow velocity
  lower limit 43
  upper limit 43
Function control, process outputs 98
Handling precautions 8
Hot Codes 19
HumanMux 38
Initialization 16
Instrument information 76
Keyboard 15
Kinematic viscosity 28
Language selection 19
Libraries 63
Main menu 17
Material list 63
Materials
  defining 65, 67
  deleting 68
Measurement
  starting 34
  stopping 35
Measuring channels, selection 29
Measuring point
  points to avoid 23
  selection 21
Measuring point designation 50
Measuring principle 11
Media
  defining 65, 67
  deleting 68
Medium list 63
Medium parameters, input 27
Memory capacity 88
Model code 121
Online output 51
Output format 52
Output of measured values 51
Output range 96
Output to a PC 51
Output to a printer 51
Parameter records 57
  deletion 58
ParaPool 59
  creating a record 61
  enabling 59
  loading a record 59
Partitioning 65
Pipe circumference 25
Pipe lining 26
Pipe lining thickness 27
Pipe material 26
Pipe outer diameter 25
Pipe roughness 27
Process outputs 95
  activating a current output 100
  activating a frequency output 100
  activating a pulse output 101
  activating an alarm output 101
  circuits 99
  configuration 95
  error value 97
  error value delay 99
  function check 98
  output range 96
  output value in case of error 97
Program branches 17
Quantity of measurement, selection 37
Reckoning channels 44
  measuring 46
  parameters 45
Reset 16
Safety precautions 3
Sample rate 50
Scope of delivery 7
Selection lists, edition 63
Serial interface 51
Settings
  dialogues and menus 72
  measurement 74
Signal LED 19
Sound path factor 29
Sound velocity measurement 91
Sound velocity measurement with WTM 79
  measuring 82
  parameter input 80
Sound velocity of the material 26
Sound velocity of the medium 27
Specifications 117
Storage 49
  activating/deactivating 49
  settings 53
  storage mode 54
  storage of the amplitude 54

storage of the sound velocity 55
storage of the totalizer 54
storage rate 50
Switching off (automatic) 20
Switching ON/OFF 15
Tables 125
Temperature of the medium 28
Time, setting 71
Time-programmable measurement
countdown 89
duration 87
enabling and disabling 85
start and stop 89
start time 85
stop time 86
Toggling between the channels 38
Totalizers 41
overflow 42
Transducer distance, display 39
Transducer parameters 28
Transducers 14
distance between transducers 30
mounting 31
positioning 33
Transit path 29
Troubleshooting 109
Unit of measurement 37
Unpacking 8
User area
partitioning 65
User materials 67
User media 67
Velocity limit 43
Wall thickness 25
Wall thickness measurement 79
activating 79
measuring 81
parameter input 80
Warranty 3